UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

MALINE CREEK ASBESTOS SITE CLOSURE AND STREAMBANK STABILIZATION STUDY

ST. LOUIS, MISSOURI

July 1993

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ABSTRACT

The subject of this study is closure of an asbestos dump site and bank stabilization along Maline Creek, a tributary of the Mississippi River in St. Louis County, Missouri. The dump site is located approximately one mile upstream of the creek's confluence with the river and it contains asbestos waste materials from two plants operated by the GAF and Certaineed Corporations until 1979. Formerly, Maline Creek's channel meandered through the property, but was straightened and relocated in 1927 to increase usable space for plant operations. Recent subsurface investigations indicate that the old channel bed and banks became the primary repository for asbestos wastes produced by those plants.

The creek drains a 25 square mile watershed which has become almost completely urbanized in the 66 years since the channel was relocated. The resulting increased rainfall runoff coupled with the stream's natural inclination to re-establish itself in its old channel bed have created inertial and frictional forces which are eroding the creek's banks, thus exposing the asbestos. Due to the increasing risk of exposing the public to potentially hazardous levels of airborne and waterborne asbestos fibers, and to prevent further pollution of Maline Creek, three remedial alternatives are proposed. The alternates use the asbestos material to stabilize the banks of the creek. In addition, those materials which have already fallen into the creek bed will be removed and used as fill material or disposed of properly.

The proposed remediation alternatives have two components: cleanup and disposal of the exposed asbestos waste material in the creek bed and stabilization to prevent future scour, erosion, and hence asbestos exposure. The three alternatives differ primarily in their channel stabilization reinforcement materials, thickness, and extent. The selection criteria for these alternates include ease of construction, maintainability, longevity, and cost.

All three alternatives have a common asbestos scrap collection and disposal method. Essentially, all asbestos material within the channel bed and along the southwest bank will be collected and placed in the northeast bank. The scrap will be sealed in benched lifts with soil to act as binder. The lifts will be further sealed in soil prior to channel lining construction. This involves shifting the channel bed to the southwest to provide working space for bench construction and to provide soil borrow to construct the benches and rebuild the embankment.

Engineering evaluation/cost analysis of the three solutions indicate that Alternate One affords the greatest protection but at the highest cost of 2,600,000 dollars. This alternate is probably the most effective long term means of controlling erosion and scour in this portion of Maline Creek. It will provide the greatest protection against re-exposure of the encapsulated asbestos scrap both along the present channel bank and in the former channel fill areas. It also represents a fundamentally different approach to solving some of the problems from that of the other two alternatives. Alternate Two and Three rely primarily upon improved channel geometry of bed and bank reinforcement to resist both the current advanced dynamic forces and the local rainfall run off or receding flood water hydraulic forces. Alternate one, however, affords superior resistance to those forces and increased protection against bank failure due to saturated soil conditions. It is most effective in sealing the asbestos scrap into a protective envelope that will shield it from natural erosive forces within the channel, and the only solution which eliminates frequent flooding as a problem source. It provides tighter control over the creek's "meandering tendencies", has relatively low maintenance requirements, and offers excellent assurance against eventual re-exposure of asbestos.

As a minimum solution, Alternate Three is recommended. While its anticipated cost of 1,567,000.00 dollars is 229,000.00 dollars greater than the 1,338,000.00 dollars cost of Alternate Two, the difference is small compared with the superior protection of the asbestos containing banks offered by the concrete lining as opposed to a reinforced turf matrix lining. It would also provide a solid base upon which an Alternate One type solution could be constructed should additional funding become available in the future.

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ABBREVIATIONS

ACM	-	Asbestos containing material
EMCB	-	Environmental Monitoring and Compliance Branch
EPA	-	Environmental Protection Agency
EPRB	-	Emergency Planning and Response Branch
fps	-	feet per second
MDNR	-	Missouri Department of Natural Resources
MSD	-	Metropolitan Sewer District
NESHAP	-	National Emissions Standards for Hazardous Air Pollutants
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Act
PSI	-	Professional Service Industries, Inc.

SECTION I

INTRODUCTION

SECTION I

INTRODUCTION

1.1 Site Location, Description, and History

Maline Creek in St. Louis County Missouri is a tributary of the Mississippi River. Approximately 1/2 mile upstream of its confluence with the river, Maline Creek flows past two industrial properties formerly owned by Certainteed and GAF Corporations. The properties begin about 700 feet east of Bellefontaine Road and are bounded on the north by St. Cyr. Road, on the southeast by Riverview Drive, and on the southwest by Maline Creek. The surrounding area is within the corporate limits of the residential villages of Bellefontaine Neighbors and Riverview Neighbors (Figure I-1).

Asbestos containing products such as transite pipe, sheeting, and insulation were manufactured on the site at least as early as the 1920s. When operations were ceased in 1979 closure plans and remediation efforts were initiated for a 17 acre common open asbestos waste dump between the two factories. The remediation activities included importing and grading clean fill material to cap the asbestos pile; installation of drainage elements and a vegetative cover; and construction of a rock blanket along 800 feet of stream bank adjacent to the asbestos pile. The plans were prepared in accordance with the Missouri Solid Waste Management Regulations current at the time and were approved by the Missouri Department of Natural Resources (MDNR). A site inspection conducted by the MDNR in May of 1980 found the effort to be in basic compliance with the regulations, although broken pipe on the creek bank southeast of the Certainteed site was noted. The Certainteed property was subsequently sold to P.G. Investments and the GAF property was sold to Clark Properties of Hazelwood, Missouri.

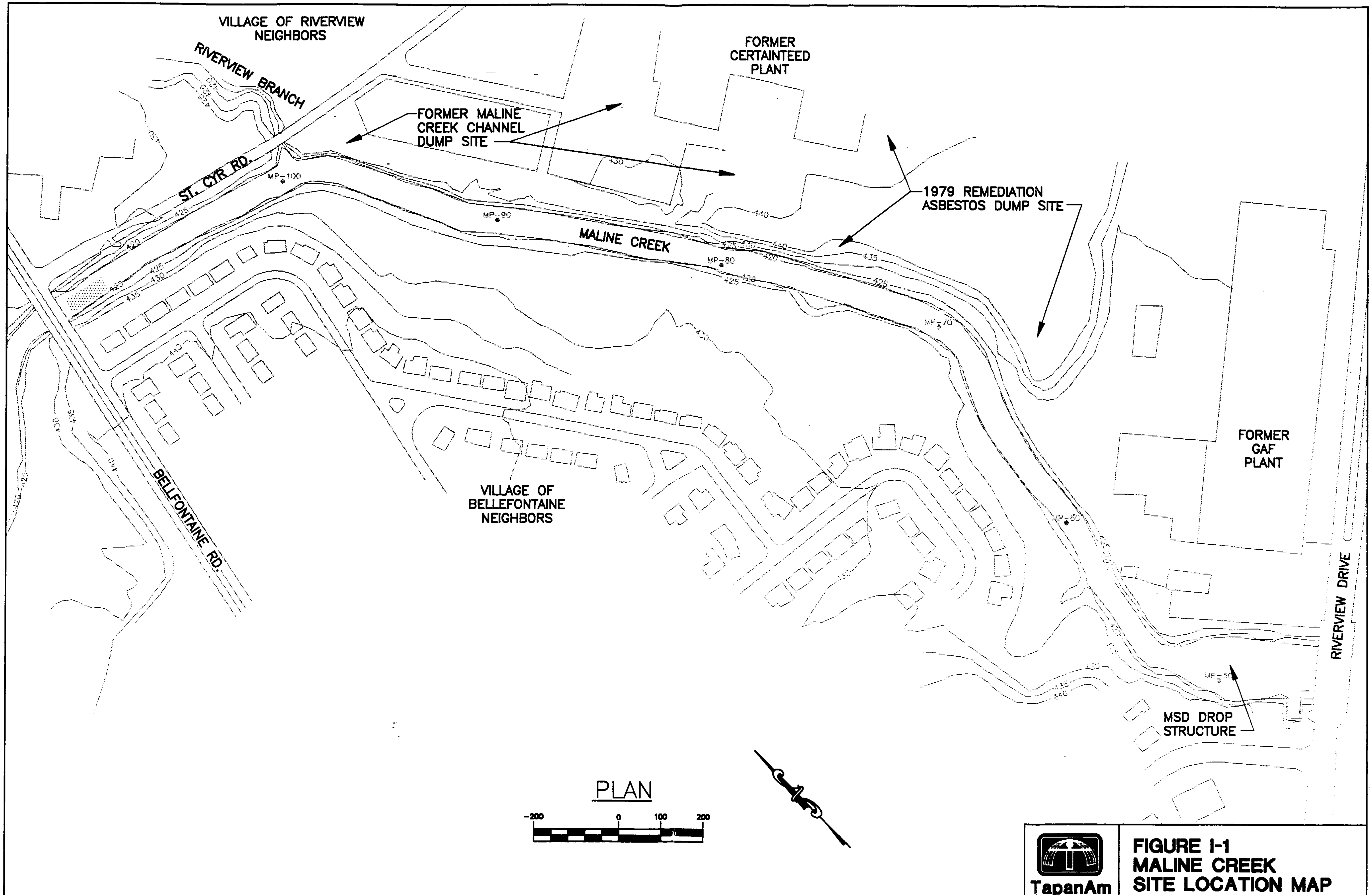

FIGURE I-1
MALINE CREEK
SITE LOCATION MAP

In 1982 contractors for the St. Louis area Metropolitan Sewer District (MSD) exposed transite pipe and other asbestos products along the creek fronting the Certainteed property during a stream bank brush and debris clearing operation. The MSD began an asbestos cleanup effort under the auspices of the MDNR. Several truck loads of asbestos scrap were removed to the Westlake Sanitary Landfill before it became apparent that the possible extent of in-place material exceeded the cleanup resources available. A wrecking ball was then brought to the site to pound the materials into the bank. The MDNR reported that approximately 1,000 square feet of scrap was left scattered on the upper portion of the bank.

Subsequent inspection of both sites performed by the EPA, Environmental Monitoring and Compliance Branch (EMCB) in May and June of 1988 discovered asbestos scrap along the bank, in the creek bed, and scattered about the two properties. Since then periodic inspections by members of the EPA Emergency Planning and Response Branch (EPRB) have been conducted and have discovered more asbestos scrap materials within the creek and its environs. Observations have also been made during field visits by consultants (Ecology and Environment Inc. and TapanAm Associates) suggesting that the extent of the scrap disposal area goes far beyond the pile remediated in 1979. It is also apparent that hydraulic erosive and scour forces are releasing the asbestos material from the banks and washing it into the creek.

Before 1927 Maline Creek described a casual meandering path through the site including one horseshoe bend (Figure I-2). The channel was later relocated and straightened to create useable space and to provide a low lying area for a dump site. Subsurface soil borings made by PSI during a TapanAm site visit in December of 1992 suggest that the

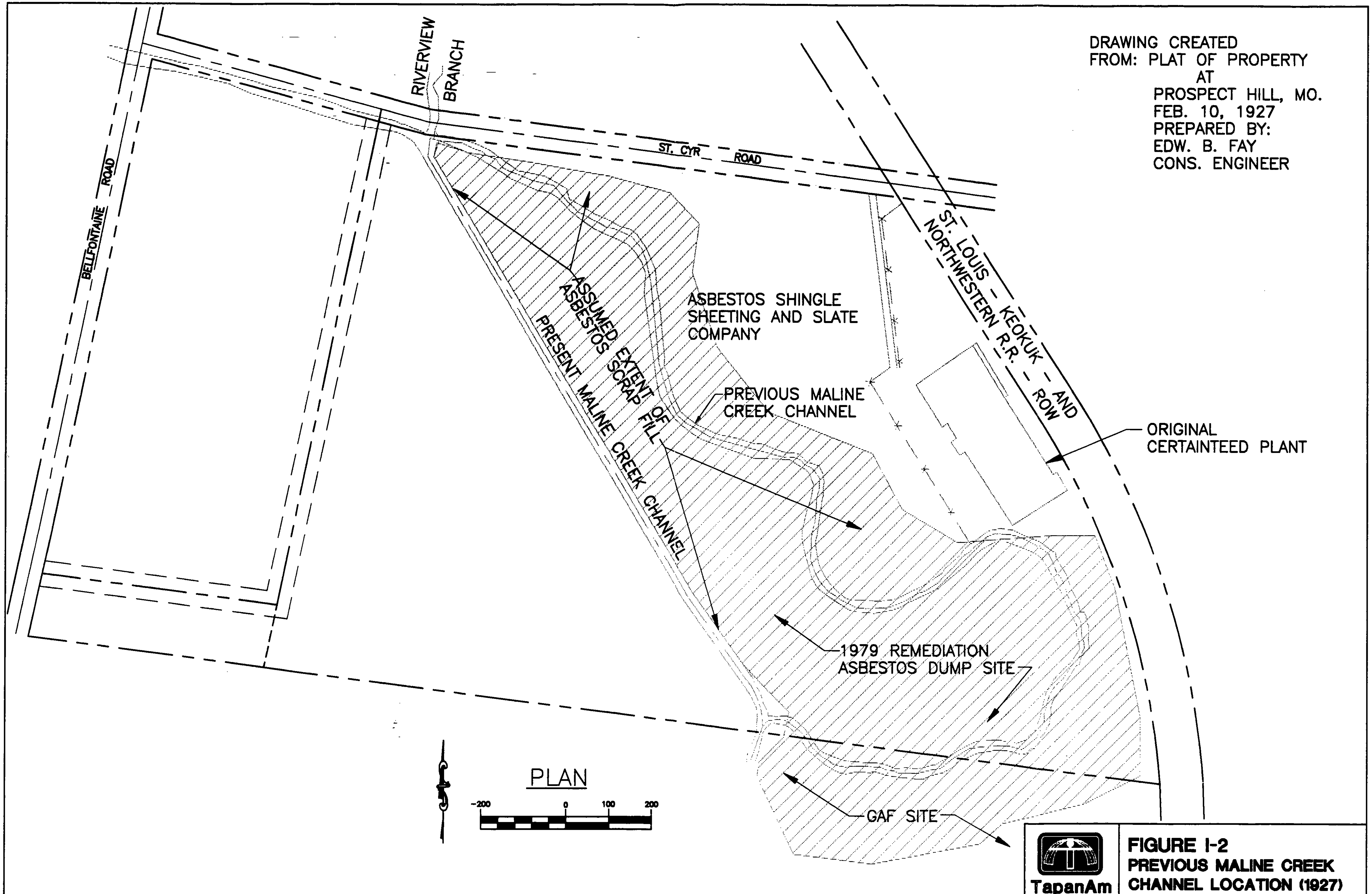

FIGURE I-2
PREVIOUS MALINE CREEK CHANNEL LOCATION (1927)

entire length of the channel bed fronting the former Certainteed property may be filled with asbestos scrap (See Appendix A). The horseshoe bend which was located between the Certainteed and GAF factories is the closure site for the asbestos scrap pile remediated in 1979.

1.2 Problem Definition

Periodic inspections and site visits have demonstrated that progressively more asbestos pipe, sheeting, insulation, and other scrap materials have been observed in and around Maline Creek since the Certainteed and GAF plants closed in 1979. Some of this material is undoubtedly from the 1979 closure site, but most of it is probably being washed into the creek from an upstream source. There is a four or more feet thick lens or stratum of such material perched within the soil matrix of the northeast creek bank. This lens apparently begins on a bend at the northwest corner of the Certainteed site and may extend 1400 feet downstream to the 1979 pile. It is part of the asbestos scrap used to fill the former Maline Creek channel as suggested by observation, subsurface borings, and the 1927 channel relocation drawing.

Storm water runoff has increased dramatically in the Maline Creek watershed since the 1920's as it has been developed and become more urbanized. The channel , therefore, has been increasing its conveyance to accommodate the greater flows by incising its bed and banks. It has also been attempting to re-establish itself within its former channel bed through a combination of erosive inertial and frictional forces unleashed at channel bends. These factors have conspired to undermine Maline Creek's northeast bank at the Certainteed GAF site, and have begun an erosion- scour embankment collapse cycle.

As portions of the bank collapse large amounts of asbestos scrap slide into the creek to be washed downstream.

Most of the asbestos scrap consists of stable transite pipe. However, friable asbestos cloth insulation, and friable solidified slurry are present. Furthermore, natural weathering processes, especially freeze-thaw cycles in the creek waters accelerate the disintegration and hence friability of the transite pipe. Airborne fibers from this material pose a public health hazard to adjacent residential areas.

1.3 Statement of Purpose

This study was initiated to investigate the sources of the asbestos materials observed in Maline Creek, to identify the hydraulic mechanisms responsible for exposing and transporting the scrap through the creek, and to suggest three alternate remediation avenues for the site. The proposed remediation alternatives will have two components: cleanup and disposal methods for the exposed asbestos scrap in the creek bed and its environs; and channel rehabilitation and stabilization methods to prevent future scour, erosion, and hence asbestos exposure.

SECTION II

EXISTING CONDITIONS

SECTION II

EXISTING CONDITIONS

2.1 Maline Creek Watershed Hydrology

The Maline Creek Watershed comprises 25.3 square miles of largely urbanized land including a small part of northern St. Louis City, all or parts of 22 other municipalities, and portions of unincorporated St. Louis County. The watershed forms a well defined dendritic network with 10.6 miles of main channel flanked by 25.6 miles of tributary channels, ranging in length from 1.4 to 4.2 miles. The area's topography is characterized by gentle sloping surfaces. Local relief is less than 300 feet and the main channel bottom slope is typically less than 1/2 foot in 100 feet.

Precipitation in the region is delivered fairly uniformly throughout the year and averages 37 inches annually. Storms seen in Missouri, however, conform to the United States Soils Conservation Service model Type II. Such storms are typically high intensity-short duration events resulting in high peak discharges during low times of concentration.

In urbanized settings, development renders large tracts of land impervious and alters natural drainage patterns. Such modifications reduce absorption and transpiration processes, and channelizes runoff thereby increasing velocities and shortening concentration times. Increases in effective runoff by factors of 4 are not uncommon in watersheds where high density development has taken place.

The St. Louis District Corps of Engineers modeled Maline Creek hydrologically and hydraulically for the survey report "Water Resources Investigation, St. Louis Metropolitan

Area, Missouri and Illinois" in September of 1980. Those hydrological and hydraulic data were subsequently updated by the Corps in the "Maline Creek Flood Control Re-evaluation Study" of 1988. The two studies investigated the impacts of a variety of alternate flood control plans on anticipated "future condition" hydrographs routed for 0.2%, 1.0%, 2.0%, 4.0%, 10.0%, 20.0%, and 50.0% probability storm events. The "recommended plan" hydrograph for the 1.0% (100 year) probability storm was selected as the benchmark event for this study. This storm delivers a peak discharge of 19,972 cfs to Maline Creek Station 0.541 miles (above the mouth of the Mississippi River) which is located just upstream of the Metropolitan Sewer District Drop Structure and downstream of the Clark Properties site at 9215 Riverview Boulevard formerly owned by GAF Corporation.

2.2 Maline Creek Hydraulics

The Metropolitan Sewer District Drop Structure at Station 0.527 miles is the point of control for water surface profiles along the Maline Creek reach adjoining the Certainteed-GAF asbestos fill sites. Throughout the reach, flow is severely restricted as a result of low conveyance due to mild channel slopes (<0.2%); inadequate cross sectional area; irregular (non prismatic) sections and transitions; and the presence of natural and man placed roughness elements such as brush, trees, rocks, failed riprap, construction debris, asbestos cement pipe, buildings, etc. Discharge through the channel is, therefore, in the subcritical flow regime and results in flooding conditions for storms of 10% probability (10 year) or greater. Extensive flooding is seen during the 1% (100 year) event when most of the Certainteed-GAF site and much of Bellefontaine Neighbors west of the creek are inundated (Figure II-1).

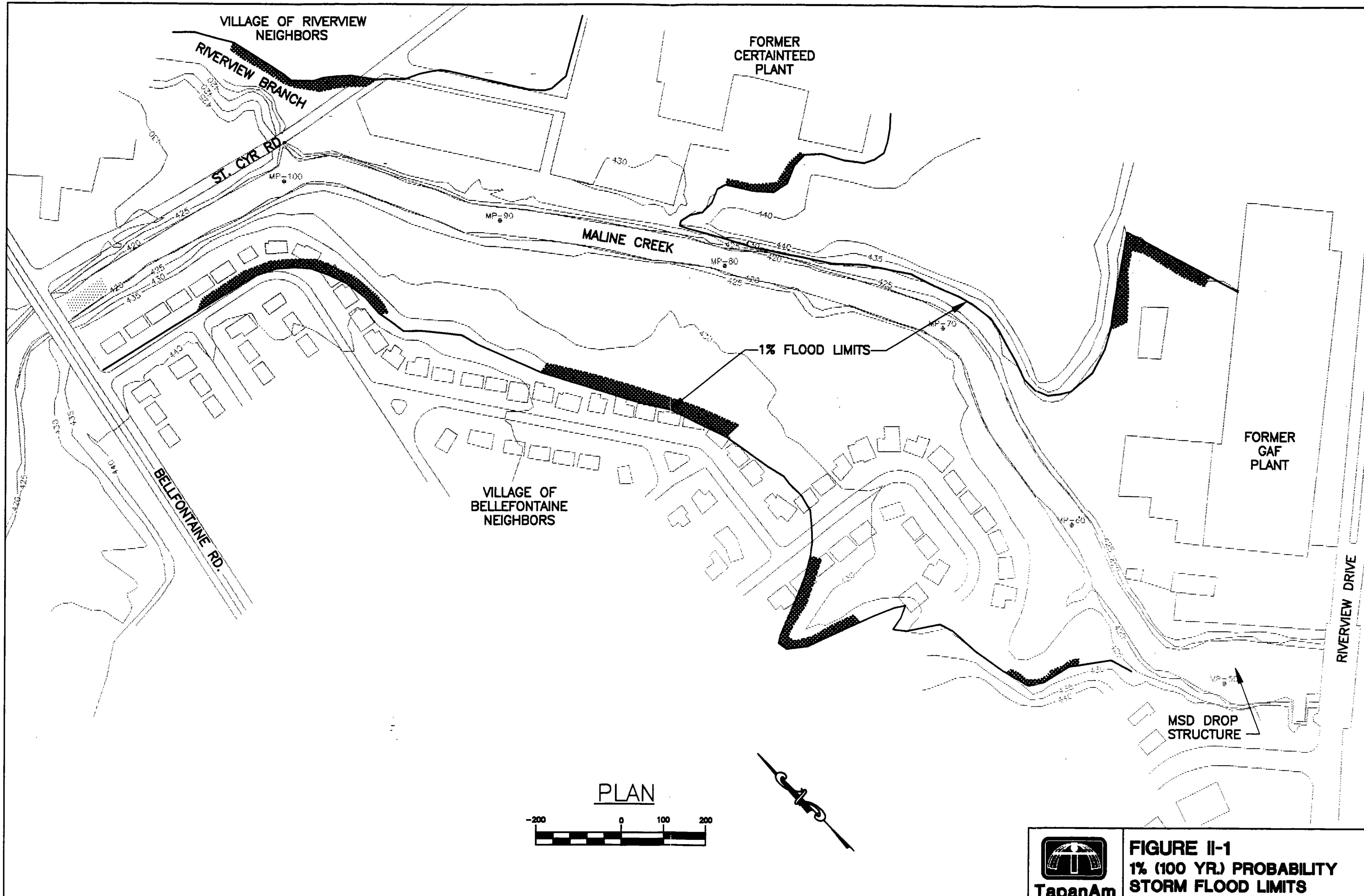

FIGURE II-1
1% (100 YR.) PROBABILITY STORM FLOOD LIMITS

The concrete paved MSD drop structure lowers the channel bottom by approximately 6 feet over a 400 feet long reach. The channel width is 43 feet with paved sideslopes ranging from 1 1/2H to 1V to 1 3/4H to 1V. At the upstream entrance to the structure the natural channel width is 35 feet whereas the exit channel width is 65 feet. The channel continues to widen as it progresses downstream to its confluence with the Mississippi. A dramatic drop in elevation (8 feet for the 1% storm) is therefore seen in water surface profiles through the structure. This draw down indicates that no influence is exerted on upstream backwater conditions by the Mississippi River or lower Maline Creek reach during local storm events.

2.3 Soils - Embankment Conditions

Soils in the Maline Creek watershed were extensively investigated by Simons, Li and Associates for the "Maline Creek Qualitative Erosion and Sedimentation Investigation Report" prepared for the St. Louis District Corps of Engineers. Subsequent geotechnical work was also initiated by the Corps for the 1988 "Maline Creek Re-evaluation Report."

According to the reports the channel bed is comprised primarily of silts and clays with some fine sands. An exposed shale outcropping was found and some portions of the bed consist of exposed clays incised by the channel. Other than the shale and exposed clay there are no natural features to offer resistance to channel degradation. However, man made improvements such as concrete encased sewer lines, rubble or riprap, and a variety of channel linings serve as gradient and hydraulic control devices of varying effectiveness.

The upper 10 to 15 feet of Maline Creek embankment is composed of very low clay content loess. Below this layer a high clay content loess or stiff clay is encountered. The more cohesive clayey soils most frequently occur in the middle and upper reaches of the creek above Bellefontaine Road. The lower reach through the Certainteed-GAF asbestos site embankment conforms to the low clay content loess profile. Loess soils are highly erosive glacial aged aeolian deposits of silt sized particles with varying degrees of cementation. Those in Maline Creek have been extensively reworked and redeposited through fluvial processes to form a silty alluvium on the flood plains.

The condition of the embankments in the vicinity of the Certainteed-GAF sites ranges from reasonably stable to severely distressed. Generally, well vegetated tangential reaches with mild bank slopes appear sound; while reaches with bare, steep or vertical banks, through bends are undergoing a dynamic cyclical undermining and collapse process.

Two 50° bends to the right (looking downstream) approximately 1/3 mile apart are within the Certainteed-GAF reach. These were created in 1927 when the original meandering channel northeast of the present day channel location was filled. The first bend is 650 feet east of Bellefontaine Road at the confluence of Maline Creek with its Riverview Branch tributary. It precedes unstable embankment conditions which continue downstream for almost 1/4 of a mile and probably represents one of the more extreme examples of streambank erosion and degradation along the creek. Even vegetated portions of the bank with trees and saplings are being undermined by flood waters. These then collapse leaving loose material which is subsequently carried downstream.

Among the materials found in the collapsing bank underlying the vegetation is the thick layer of asbestos waste products which was used to fill the old creek channel.

The other bend is located at the 1979 Certainteed-GAF asbestos waste pile. Although some side slopes in the vicinity of the pile are mild and relatively stable for the present, there is evidence that natural erosive and scouring processes are taking place; especially along the steeper slopes. The 1979 remediation effort included a 25 feet by 800 feet rock blanket placed along the regraded creek bank. This blanket has largely failed and has been washed into the channel bed or has been carried downstream by flood waters. Such failures of erosion control measures are common in Maline Creek and were frequently noted in the Simons, Li, and Associates report.

2.4 Erosion-Scour Causes and Mechanisms

The fundamental reason for the progressive erosion and scour processes seen in Maline Creek is the increasing rainfall runoff load placed on the channel in conjunction with the ongoing urbanization of the watershed. Channel equilibrium has not been achievable in the face of continuous development. Because the Certainteed-GAF site is located at the downstream extremis of the 25.3 mile watershed it is subject to the added runoff from virtually any new development activity. The channel is subsequently affected in two ways. It must increase conveyance to accommodate the added flow and a sediment deficit is created in comparison with the new transport capacity of the stream. These phenomena then result in both bank erosion and degradation of the channel profile. Simons, Li, and Associates reported that the Maline Creek channel bed has been degraded by one to three feet in recent years.

A related consequence of urbanization with particular application to this site is the developers' penchant for straightening and relocating channels to maximize useable space. Simons, Li, and Associates noted that Maline Creek has a particular "tendency to return to a meandering pattern." This tendency is especially evident along St. Cyr Road east of Bellefontaine Road and at the Riverview Branch tributary bend where the undermining and erosion processes are attributable in part to the creek's efforts to establish itself in its former channel. Although Simons, Li, and Associates do conclude that the rate of future channel bed degradation in Maline Creek will probably diminish because the watershed is now almost completely urbanized and most of the bed has been incised to the more scour resistant clay layer; erosion of the bank will continue and is of special concern for the fragile low clay content loess banks below Bellefontaine Road.

Erosion-scour processes are complex phenomena with a variety of concurrent causes. Foremost among them is the tractive force (shear or drag force) acting on the channel bed and sides in the direction of flow. It is often associated with a "maximum permissible velocity" which in alluvial silts similar to the loess seen in Maline Creek is 2 fps for clear water and 3.5 fps for water transporting colloidal silts. Given the sediment deficit in the flow noted by Simons, Li, and Associates, the "maximum permissible velocity" for Maline Creek is probably closer to the lower 2 fps figure. That velocity is low even for tranquil subcritical flow and is probably often exceeded throughout the length of the creek. Where bends, obstructions, and sudden transitions are encountered additional inertial and frictional forces are introduced which accelerate the flow. These result in higher momentum, vortices, and eddying currents, which promote scour and erosion. Both natural and manmade features inducing such acceleration are common to the creek.

Simons, Li, and Associates routed the 10% and 1% probability storms through 14 Maline Creek bridges and noted that most velocities were considerably in excess of 3.5 fps with many exceeding 10 fps.

The spiral currents generated as water moves through bends are of particular concern in the Certainteed-GAF reach. This phenomenon is peculiar to subcritical flow and accounts for much of the embankment scour which can be seen even in some relatively tranquil streams. Such currents describe a helical path in the direction of flow and introduce transverse velocity components to the channel section (Figure II-2). These currents are believed to be caused by filamental velocity differences between the center of the channel and the channel wall induced by friction; centrifugal force which deflects water particles from straight line motion; and a vertical velocity distribution in the approach channel which initiates the spiral motion. Looking downstream, a bend to the right induces counterclockwise motion, while a bend to the left induces clockwise motion. Such currents are probably the primary reason for the severe undermining process seen at and below the Riverview Branch tributary bend. Spiral currents tend to persist for some distance downstream when a curve is followed by a long straight tangent and, therefore, their impact is not merely local. The extensive damage done along the Certainteed-GAF northeast bank well below the bend is a prime example of their effect.

In addition to the dynamic hydraulic forces acting on the channel and its banks induced by the current, there are local erosive forces at play. Among these is the sheet flow over the stream banks initiated by rainfall runoff or receding flood waters from contiguous drainage areas. Such runoff causes gullying and rilling in proportion to the erosive potential of the soil and the erosion resistance ability of the channel lining.

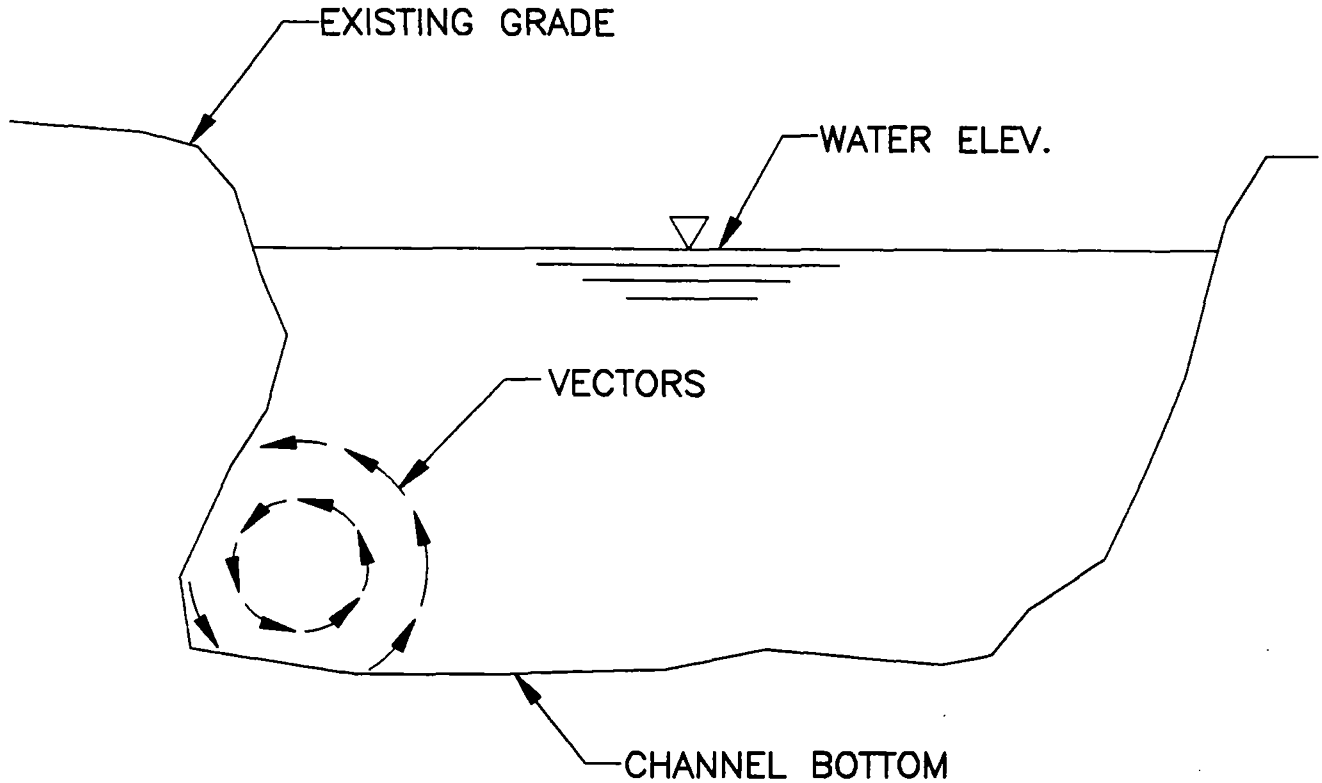

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FIGURE II-2
CREEK SECTION SHOWING SPRIAL FLOW VELOCITY VECTORS

Two failure mechanisms are possible when bank soils are frequently saturated. One leads to a gradual failure as material is leached from the banks over time, while the other leads to a precipitous collapse due to differential pressures between the soil envelope and the open channel section. This sudden draw-down effect is most often seen after a period of sustained rainfall when surrounding soils are saturated to capacity. The shear strength of the soil-water mixture is considerably less than that of the soil in its normal state, while the weight and hence the pressure exerted by the mixture is much greater than normal. When the hydrostatic pressure opposing the saturated soil pressure is relieved during drawdown as flood waters recede, a precipitous collapse of the bank often ensues.

SECTION III

ASBESTOS STUDY

SECTION III

MALINE CREEK ASBESTOS STUDY

3.1 Introduction

The approximate boundaries and depth of the asbestos waste pile in the Maline Creek area was determined by subsurface drilling operations. Twelve bore holes were drilled using a profile auger each to a depth of twenty feet. The surface contamination was determined during the site inspection.

3.2 Surface Contamination

Asbestos containing materials are exposed in the creek bank, bottom of the river bed and on the surface. The most visible contaminations is along the east bank of Maline Creek near St. Cyr road, where a stratum of white asbestos containing material is exposed to the surface. This layer of asbestos material is about two feet below the surface and is about two to five feet in thickness. This stratum is exposed along the bank for about 300 feet in length (Figure III-1 and III-2).

The majority of the asbestos pile in the creek bed is caused by collapse of asbestos material from the bank into the creek bed where water has undermined the soil beneath the stratum (Figure III-3 and III-4). Water has subsequently carried some of this debris downstream, scattering pieces of cement asbestos pipes along the entire length of the creek.

On the surface, in the wooded area along the top of the east bank of the creek, broken pieces of pipe lie scattered amongst the rip-rap and vegetation. More asbestos material is exposed to the surface in the northwestern part of the property where the cap is only

Figure III - 1 Looking North at approximately 1/2 mile SE of Riverview Branch tributary.

Figure III - 2 Close-up of NE bank from Riverview Branch tributary, approximately 1/2 mile SE of tributary to show stratum of asbestos materials

Figure III - 3 Looking SE from Riverview Branch tributary to show asbestos material on creek bed.

Figure III - 4 Close-up to show asbestos material scattered on creek bed, looking south at Maline Creek from Riverview Branch tributary.

a few inches thick. Broken pieces of pipe litter the asphalt parking lot where half buried cement asbestos pipes are used as wheel stops. Small piles of asbestos debris are scattered around the southern edge of the property which abuts the old GAF property. Asbestos pipes are also exposed around the base of the high voltage electric wire Transmission Tower located at the southern edge of the main parking area.

3.3 Subsurface Contamination

Twelve bore holes were drilled to determine the subsurface level of contamination. The location of bore holes is shown in Figure III-5 and the bore hole logs are included in Appendix A.

Materials encountered in the boring consisted of fill materials overlying alluvial deposits consisting of silty clays and silts. The fill material consisted of cement asbestos debris, sand, gravel and silty clays.

It is evident from the borehole data that much of the fill material used during the 1927 creek re-alignment project consisted of cement asbestos debris. The thickness of the asbestos bearing fill material ranged from seven feet to the full twenty feet depth of the boring. Fourteen feet of asbestos material was encountered at boring location B1, twenty feet at boring location B4 and eight feet of asbestos material at boring location B8. The soil cap covering the asbestos debris varied from one to two inches in the north to six to seven feet in the south at boring location B6.

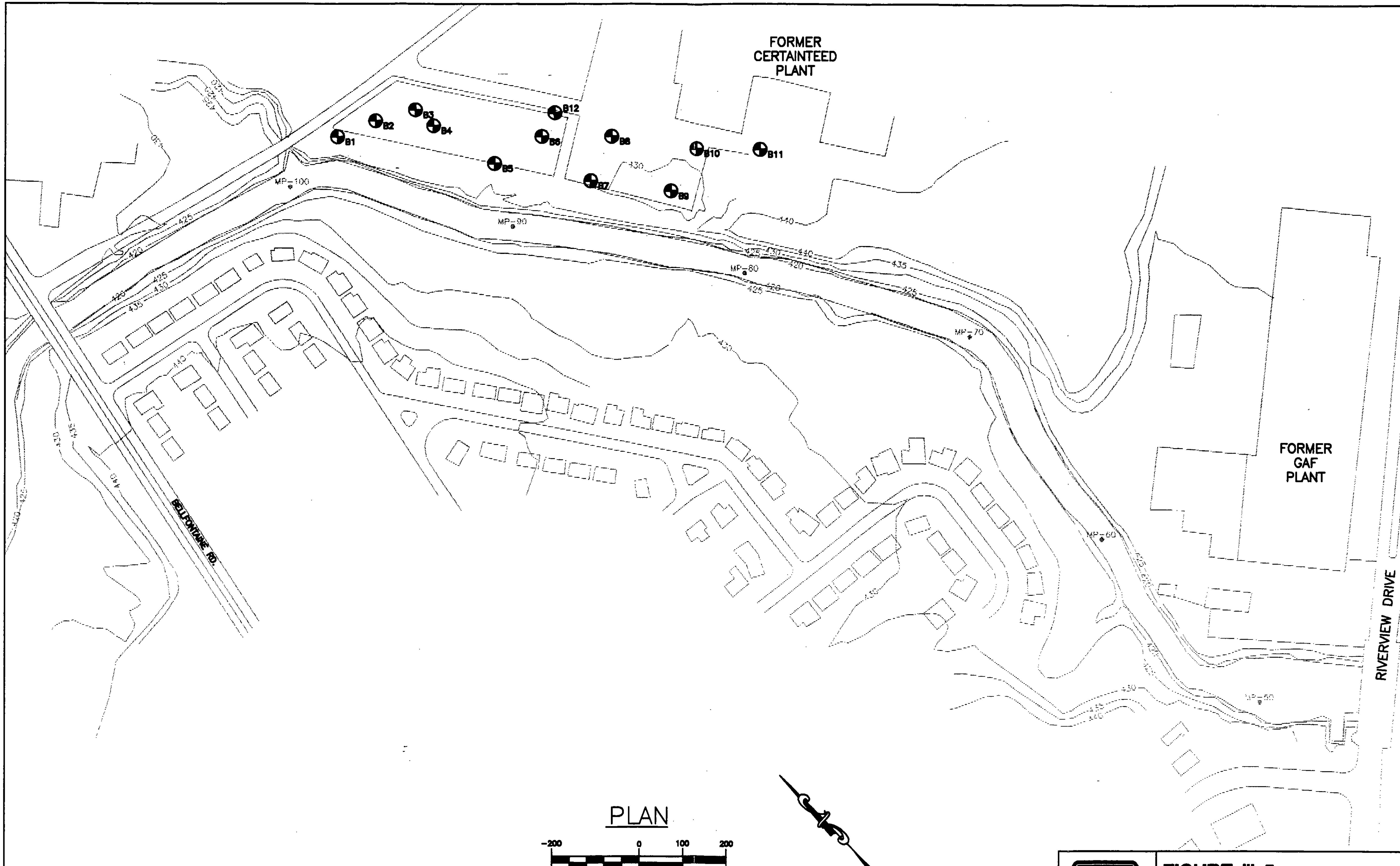

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FIGURE III-5
SUBSURFACE INVESTIGATION BORING LOCATIONS

3.4 Asbestos Materials

The vast majority of exposed asbestos containing materials (ACM) located on the subject property is cement asbestos pipe sometimes referred to by the brand name Transite. Other asbestos containing materials identified among the debris include broken pieces of corrugated cement board, pipe collars, impregnated cloth, pipe insulation and solidified slurry mixtures (Figure III-6 and III-7). According to NESHAPs regulations, the pipe and siding materials identified in the area are classified as Category II nonfriable ACM. These are materials which release significant levels of asbestos when crumbled or pulverized.

The EPA Final Rule Act 40 CFR 763 Subpart E, defines asbestos containing materials as any material which contains more than 1% asbestos. Insulation and cement pipe debris identified in the bore holes contained about 85 to 90% asbestos. The cement board contained about 20% asbestos. The primary asbestos mineral found in these materials is chrysotile. Crocidolite was also detected in the pipe and insulation materials.

Friable materials identified at the site include pipe insulation, impregnated cloth and solidified cement slurry. Weathering and deterioration of non friable materials may lead to delamination, where the material begins to split and pull apart thus releasing fibers.

The materials in the creek bed showed signs of advanced deterioration probably due to water erosion and freeze thaw actions. Other factors noted as contributing to the breakdown of the non friable materials include stress induced by plant roots and vehicles running over the materials scattered in the parking area.

Figure III - 6 Transite pipe, connectors and pipe collars along NE bank from Riverview Branch tributary.

Figure III - 7 Close-up of asbestos pipe in solidified slurry.

3.5 Asbestos Regulations

Asbestos is one of the known human carcinogens. Inhalation of airborne asbestos fibers can produce lung cancer, mesothelioma and other respiratory diseases. Asbestos is regulated in workplace by Occupational Safety and Health Administration (0SHA). Regulations such as NESHAPs Final Rule were promulgated to reduce the emission of asbestos fiber into the air. US EPA has implemented regulations for asbestos present in schools, for asbestos removal from buildings, asbestos concentrations in drinking water and disposal of asbestos waste material. Under the EPA 1986 Safe Drinking Water Act & Regulations, public water systems may contain no more then 7 million asbestos fiber greater than 10 microns in length per liter. However, no regulations exists for exposure to asbestos in ambient air, non-occupational settings near asbestos deposits or asbestos construction materials such as Maline Creek asbestos dump site.

3.6 Hazard Potential

According to the PSI report it is not likely that a person walking in the area would inhale a hazardous amount of asbestos fibers. However, due to the increasing amount of exposed material, and the continued deterioration of the materials, the potential for exposure increases with time.

The possibility of asbestos fibers being present in the creek water poses two scenarios which would result in being hazardous to the public. The first scenario is that the fibers in the water will be deposited on a surface which when dries causes the fiber to become airborne. Due to the quantity of material in the creek and the continual change in water level in the creek, this situation is a viable concern. The second scenario is that the fibers make their way to the Mississippi River and then into the intake of public water system.

Investigation of exposures to environmental asbestos by Black et al, (1989) suggested that wind erosion is not a significant mechanism in asbestos fiber entrainment at the Superfund site at Alviso, a suburb of San Jose, California. They suggested that mechanical soil disturbance action may be more important than wind in creating asbestos fiber. It is more likely that asbestos in community air is caused by soil disturbing activities such as vehicle traffic.

3.7 Removal & Handling Recommendations

3.7.1 Removal

Due to the increasing risk of exposing the public to potentially hazardous levels of airborne asbestos fibers, and to prevent the further pollution of Maline Creek, three remedial alternatives are proposed. The alternates propose to use the asbestos material to stabilize the banks of the creek. However, in order to accomplish the task of stabilizing the creek bank, some of the asbestos-containing material on the property adjacent to the bank will be disturbed. In addition, those materials which have already fallen into the creek bed will be removed and used as fill material or disposed of properly.

3.7.2 Handling

During the process of cleaning up and stabilizing Maline Creek, protective measures should be taken to insure the safety of personnel involved in the cleanup work and the general public. Although most of the ACM involved is of the nonfriable variety, it would not be possible to separate out the friable material for separate handling and disposal. In addition, it is not practical to assume that the nonfriable materials will not be broken during handling. Due to the size and quantity of asbestos-containing materials involved, heavy equipment such as bulldozers and dump trucks will have to be used to perform most of the abatement work.

Essentially this project involves the reopening of an existing inactive asbestos waste disposal site. This type of operation is covered by the NESHAP regulations. Standard 61.151 of the Final Rule pertains to inactive waste disposal sites for asbestos mills and manufacturing and fabrication operations. In this standard it states that written notice must be provided to the NESHAP administrator at least 45 days prior to excavating or otherwise disturbing any asbestos-containing waste material that has been deposited in a waste disposal site. The administrator in this case is the St. Louis County Department of Health, Air, Land & Water Branch, Air Pollution Control Section. This agency has been given the task of enforcing the NESHAP regulations by the Missouri Department of Natural Resources, who in turn is tasked by the EPA. The County Department of Health also requests that a notification of asbestos removal be submitted on their standard notification form.

Once the abatement/restabilization work begins, the site then becomes classified as an active waste disposal site. Standard 61.154 of the NESHAP regulations provides the guidance for this type of operation. The regulation states that during operations there must be no visible emissions to the outside air. Materials should be wetted before removal and kept wet during handling to minimize dust emissions. The operator of the disposal site should cover the asbestos-containing waste material, that was deposited that day, with six inches of compacted soil. Alternate dust control methods may be used if approved by the EPA.

Although the NESHAP regulations provide us with the minimum requirements for conducting a task such as this, due to the creek and close proximity of the work site to a residential neighborhood, additional precautionary measures are recommended.

Protective measures must be taken to assure the safety and protection of the environment, the general public, and those personnel performing the work.

The primary goal to achieve in regards to maintaining a safe environment and complying with current regulations during relocation of the asbestos material is to release no visible emissions. In order to accomplish this goal, proper handling techniques will have to be practiced and special engineering controls utilized. Materials should be wetted before removal and kept wet during handling. In addition, a daily cover of six inches of soil will be placed over the exposed material to prevent visible emissions. Filtering or settling of the creek water will be necessary to prevent contaminated effluent from continuing on down stream. A decontamination unit should be installed to allow an area for workers to change clothes, to establish the boundary between the controlled area and clean area, and to provide a common point of ingress and egress to the area. Under the Resource Conservation and Recovery Act (RCRA) 40 CFR 257, EPA requires that access be controlled to prevent exposure of the public to potential health and safety hazards at the disposal site. Therefore, it is recommended that warning signs should be posted notifying the public of the danger of breathing asbestos dust, and temporary fencing installed around the work site to keep unauthorized people out of the area. Gates which can be locked during off hours should be installed. Personnel working in the area, including equipment operators, should have proper training in the handling and removal of ACM, and be equipped with personal protective equipment applicable for these type of activities. After the abatement work is complete, all tools, equipment, and vehicles used on the project should be decontaminated and inspected prior to leaving the job site.

The purpose of maintaining no visible emissions is to keep the airborne asbestos fiber concentration level to a minimum. A comprehensive air monitoring program should be maintained throughout construction to assure that the proper level of protective equipment is being worn by the workers, to confirm that adequate wetting and handling procedures are being practiced, and to assure the general safety of the public in surrounding areas. Air monitoring also provides a documented record of the environmental conditions throughout the project.

3.8 Disposal Method And Final Cover Recommendations

3.8.1 Disposal

Any materials which can not be placed back on the site property may be taken to the Missouri Pass Landfill on Page Street in St. Louis County, or any other sanitary landfill which accepts asbestos waste. All asbestos wastes transported off site must be in impermeable containers. A practical means for a large scale project such as this one would be the use of "bladder bags"; large polyethylene liners which fit inside 20 or 40 cubic yard roll-off type waste containers. Warning signs would be posted on the containers during loading and unloading. The containers would be covered during transport.

The transporting and disposing of ACM is a complex and expensive task. Transported materials must be containerized and moved in a enclosed vehicle. Special paperwork must be completed by all parties involved in taking these materials off site to another location. It is recommended that as much of the asbestos material be placed back onto the subject property to be used for channel stabilization as fill material.

3.8.2 **Final Cover**

The removed asbestos material will be used as fill behind the retaining structure constructed to stabilize the creek bank. Materials buried on site should not be compacted until the daily six inch cover has been put in place. In accordance with NESHAP regulations, 40 CFR Part 61, all asbestos-containing debris must be covered with a minimum of six inches of soil and maintain a suitable vegetative cover on the area adequate to prevent exposure of the asbestos containing waste material. However, due to the vicinity of the asbestos site to the Maline Creek and residential areas, we recommend that a final cover of at least 2 feet of soil with a vegetative cover be utilized on the areas where asbestos materials are currently exposed. This extra thickness of soil is proposed to prevent future erosion and exposure of the buried asbestos material.

SECTION IV

ENGINEERING SOLUTIONS AND COST ESTIMATES

SECTION IV

ENGINEERING SOLUTIONS AND COST ESTIMATES

4.1 General Discussion- Stabilization Techniques

Natural channelization is a dynamic process leading to the stabilization or maturation of stream beds and banks. Among the mechanisms active in the process is the meandering phenomenon where the channel bed slope and hence the flow velocity are lowered as the stream follows a winding path. Frequent direction changes described through compound curves and countercurves dissipate more energy and further reduce velocity. These compound and reverse curves also dampen and compensate for the spiral currents which would otherwise form at the simple curve bends followed by long tangent sections typical of man made or modified channels. Stream meandering, then, lowers flow velocity reducing tractive force, and dampens or eliminates the highly erosive transverse forces caused by spiral currents.

Sediment transport is another natural stream stabilization and maturation mechanism. When the transport capacity of a given discharge or flow through a stream and the sediment load in that discharge are in equilibrium then no further erosion may take place. An urbanized watershed, however, contributes far more runoff to the stream at much higher velocities than it would in its undeveloped state. Furthermore, a significant portion of its soil surface, has been rendered impervious through paving and roofing activities. Thus stream sediment transport capacity has been increased, while much of the overbank silt source has been eliminated. The channel bed and bank then become the primary source of material to satisfy the increased sediment transport demand.

The rechannelization of natural streams is a common byproduct of urbanization. The effort often involves the construction of more prismatic or uniform channel sections and channel straightening. It is usually initiated to increase usable space for development and to increase channel conveyance as a flood control measure. Once begun the process is difficult if not impossible to reverse. The eroding GAF-Certainteed Maline Creek reach is a good example of some of the long term adverse effects of the process and the difficulty of mitigating those effects. Re-establishing the creek's original meandering route through the now developed asbestos scrap infilled property is obviously not among the options available to help correct the problem and prevent future erosion. Therefore, solutions must be found to stabilize and then reinforce the creek bank to avoid re-exposure of the asbestos after remediation.

Three alternatives are offered for consideration. They are essentially variations on the same themes and involve reinforcing the channel bed and embankments to resist the hydraulic forces at work, and the construction of a more prismatic and transitionally smoother channel to dampen some of those forces. Local erosive phenomena will be abated by providing surface intercept and sub-surface drainage features where appropriate. The three alternatives differ primarily in their channel stabilization reinforcement materials, thickness, and extent. The selection criteria for these alternates include ease of construction, maintainability, longevity, and cost.

All three of the alternatives have a common asbestos scrap collection and disposal method. Essentially, all asbestos material within the channel bed and along the southwest banks will be collected and placed in the northeast banks. The scrap will be sealed in benched lifts with soil to act as a binder. The lifts will be further sealed in soil prior to channel lining construction (Figure IV-1). This will involve shifting the channel bed to the southwest to provide working space for bench construction and to provide soil borrow to construct the benches and rebuild the embankment.

After examining a variety of channel section shapes and linings along the improved reaches of Maline Creek, including many which have failed, Simons, Li and Associates concluded that three typical sections were appropriate for use in modifying the creek depending on local hydraulic conditions (Figure IV-2). The Metropolitan Sewer district which has experimented with a number of section shapes and linings will accept most competently engineered solutions. However, the MSD will only assume maintenance responsibilities for vertical reinforced concrete retaining walls with reinforced concrete channel bed linings. Retaining wall structures are extremely expensive. One installed on Blackjack Creek, a tributary of Maline Creek, by the MSD cost $700.00 per foot to build. To construct such a channel at the downstream terminus of a 25 square miles watershed subject to the vicissitudes of weather during construction would be prohibitively expensive. Therefore, the preferred MSD solution is not among the alternatives selected for investigation in this study.

Three solutions which are consistent with current hydraulic engineering practice and are cost effective for the desired level of protection are offered. They all utilize methods and materials selected for ease and relative economy of construction and are compatible with construction in an actively flowing stream subject to the occasional storm.

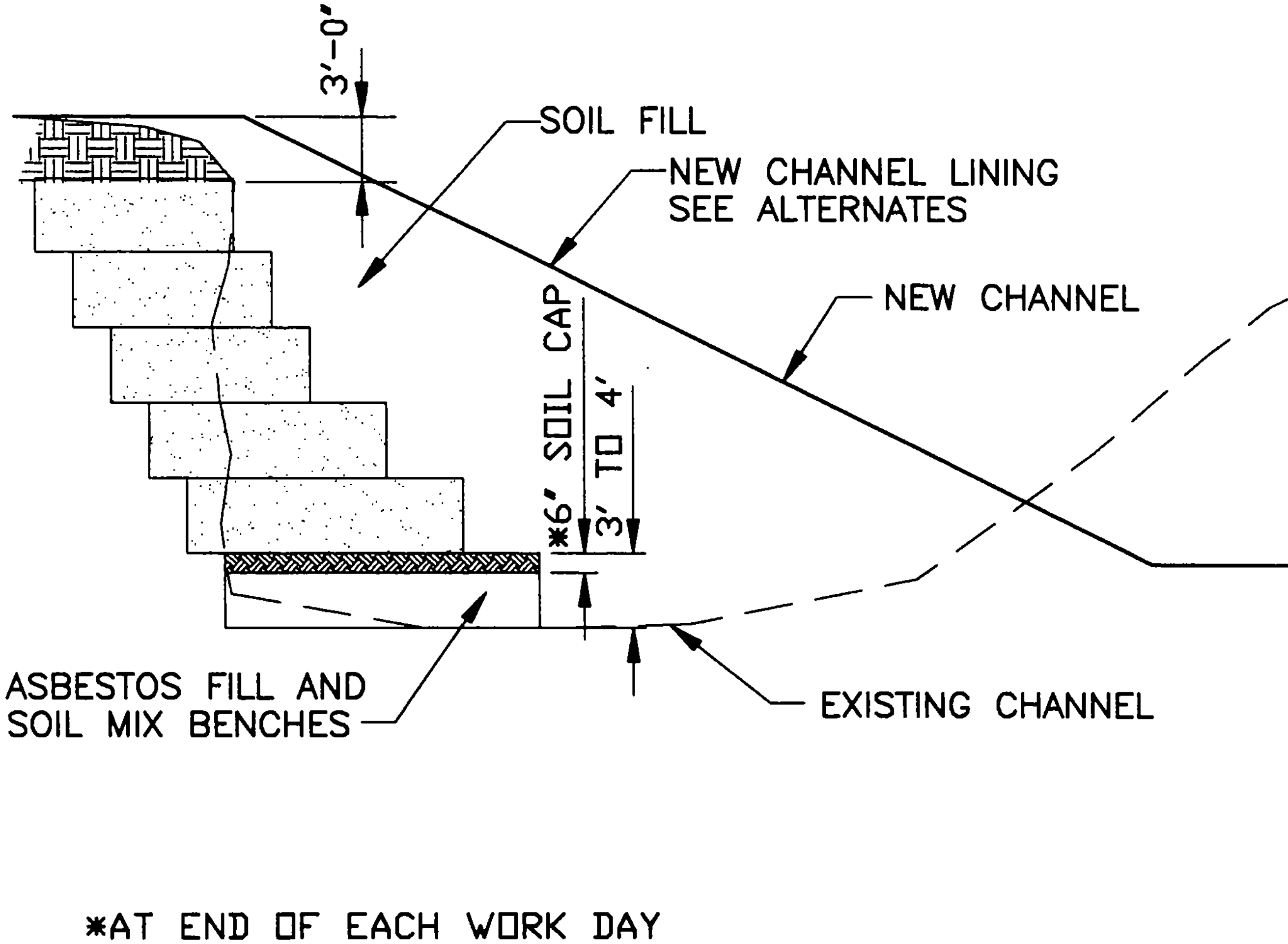

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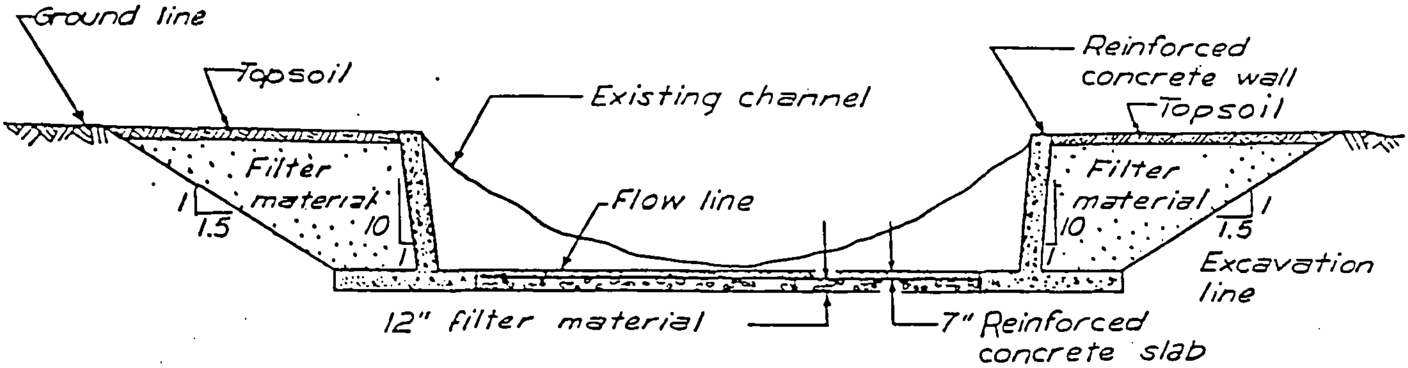
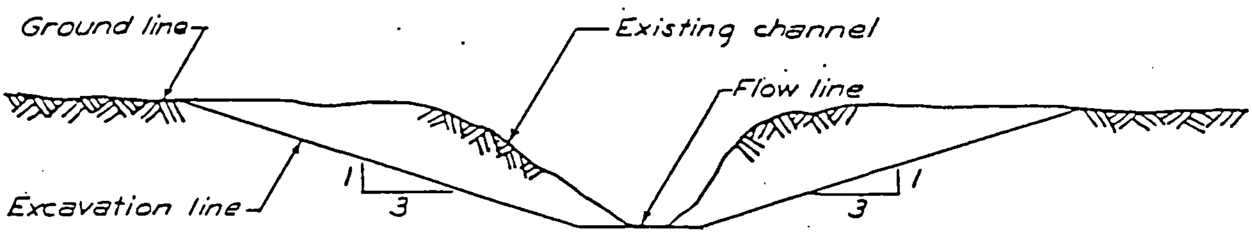
FIGURE IV-1
SUGGESTED ASBESTOS DISPOSAL & STABILIZATION TECHNIQUE



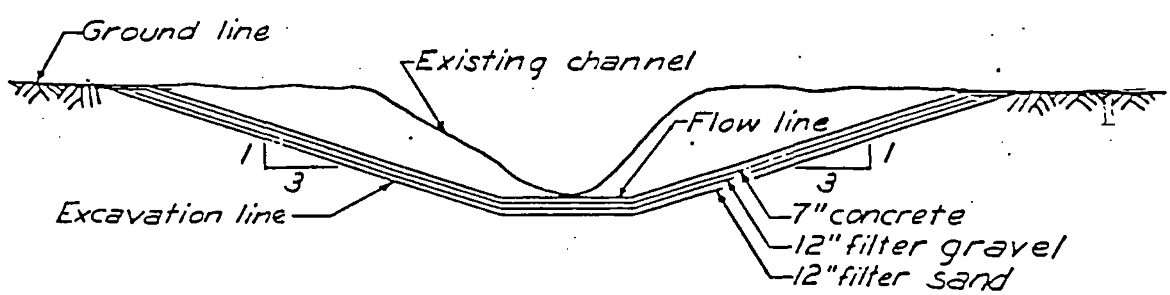
U-SHAPED CONCRETE CHANNEL

NO SCALE



TRAPEZOIDAL EARTH CHANNEL

NO SCALE



TRAPEZOIDAL CONCRETE CHANNEL

NO SCALE

Figure IV - 2 **Typical sections of proposed channel modifications. By Simons, Li and Associates (1985)**

4.2 Alternate No. One

Among the three solutions investigated this alternate affords the greatest protection, but at the highest cost. It anticipates that the entire channel will be lined from Bellefontaine Road to the MSD drop structure (Figure IV-3). The tangent reach between the two major bends will be shifted to the south by as much as 40 feet and the channel bed within the reach will be increased to a width of 50 feet. The bed will be lined with a 12 inch thick gabion revetment, while the banks will be constructed at a 2 to 1 slope and lined with a 6 inches thick Geoweb cellular confinement system infilled and capped with 8 inches of concrete (Figure IV-4).

The approach and departure reaches from Bellefontaine Road to the first bend and from the second bend to the MSD drop structure respectively will have a 35 feet wide 12 inches thick gabion revetment bed placed within the existing channel bed. The embankment slopes will be 1½ to 1 and will be lined with an 8 inches thick Geoweb system infilled and capped with 10 inches of concrete (Figure IV-4).

Alternate One will take approximately 22 weeks to complete (Figure IV-5). Its construction material quantities and opinion of probable cost are contained in Table IV-1.

4.3 Alternate No. Two

Alternate No. Two is the least costly of the three. It differs from Alternate No. One in that concrete is used as a channel lining only in the vicinities of the two bends; the channel is shifted farther to the southwest to accommodate milder embankment slopes; and no channel work is proposed upstream of the Riverview Tributary bend or downstream of the 1979 remediation pile bend (Figure IV-6).

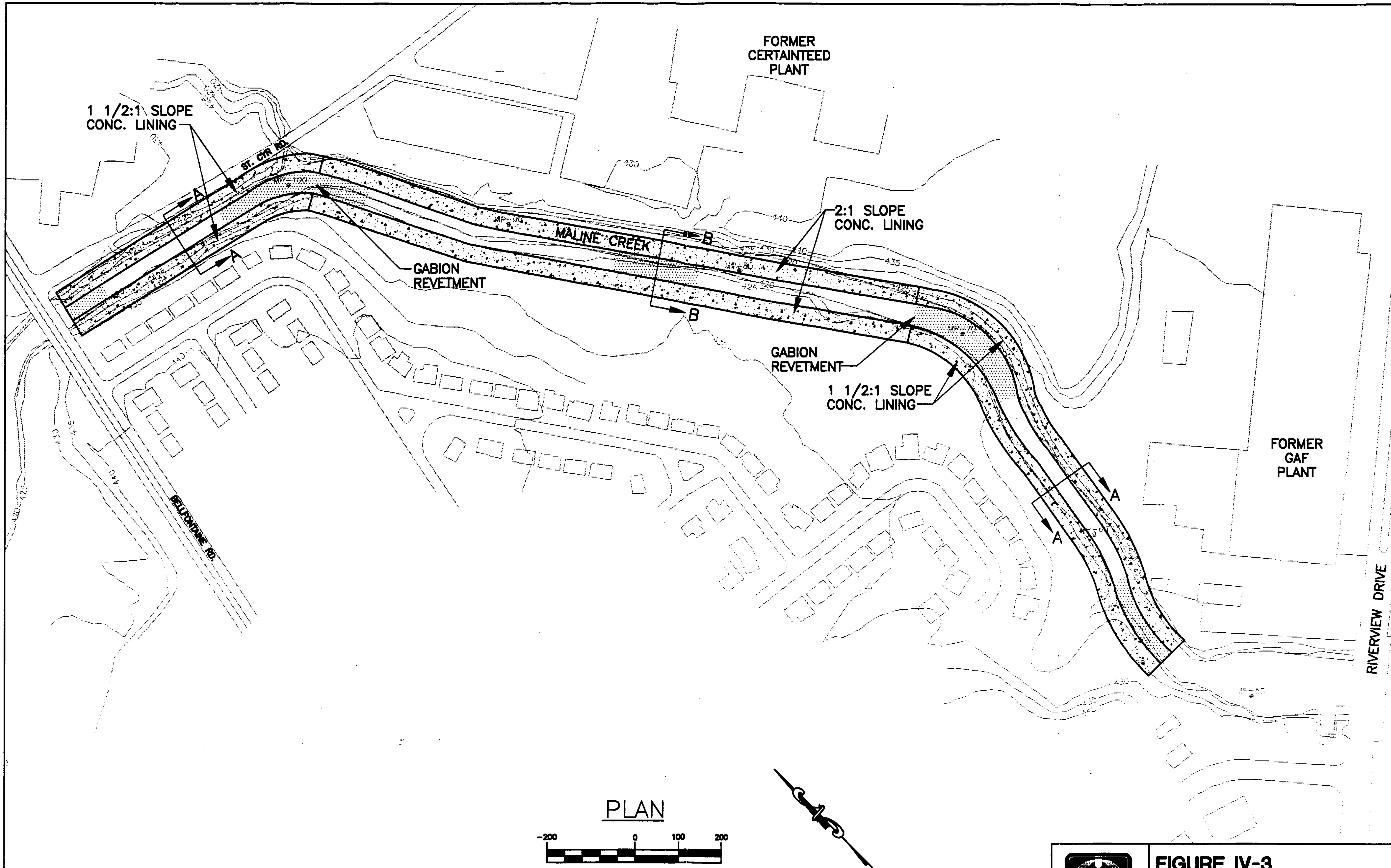


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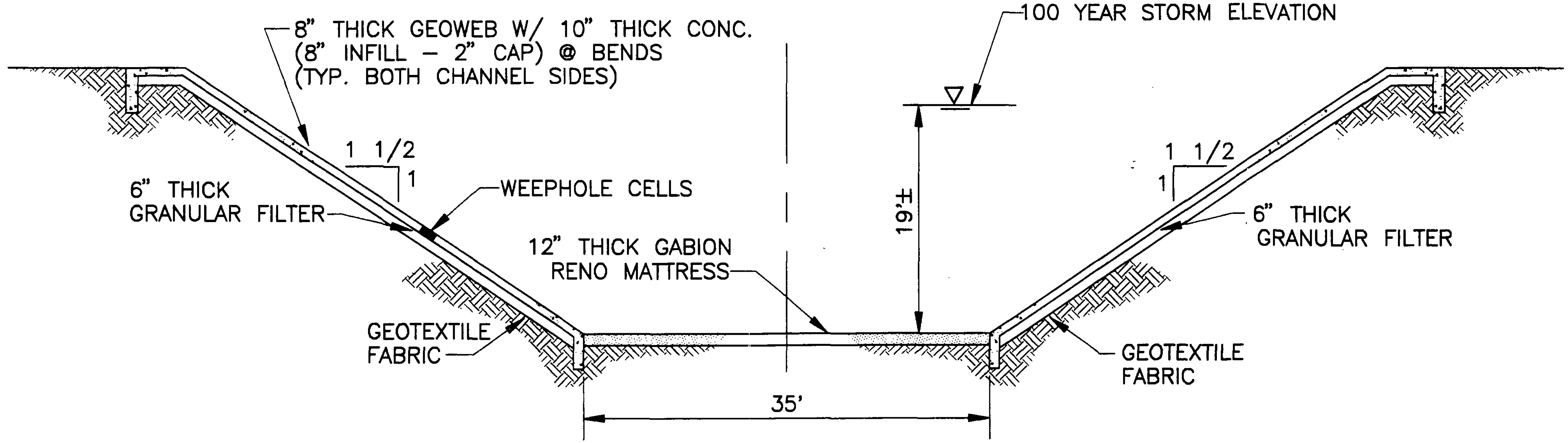
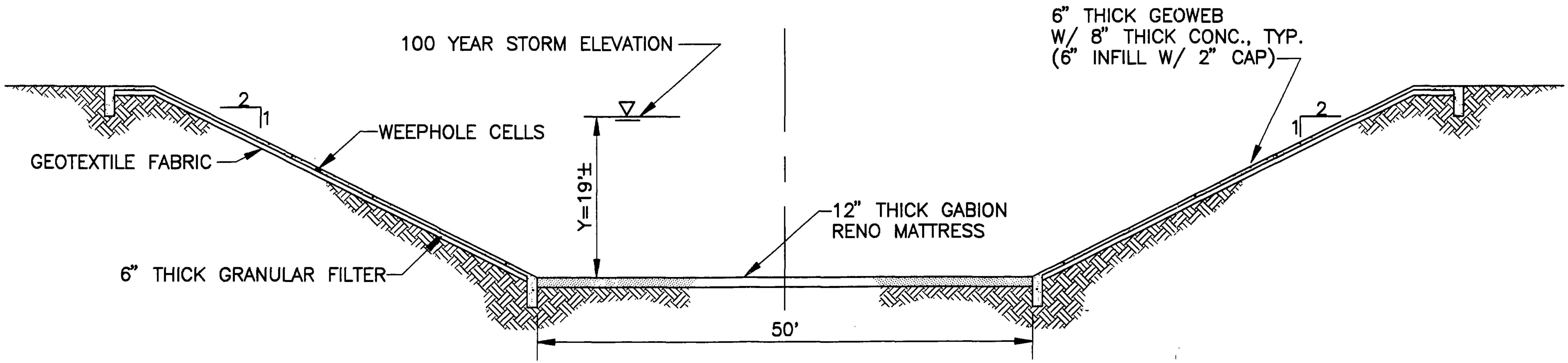
FIGURE IV-3
ALTERNATE NO.1 PLAN



SECTION A



SECTION B

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FIGURE IV-4
ALTERNATE NO.1
SECTIONS

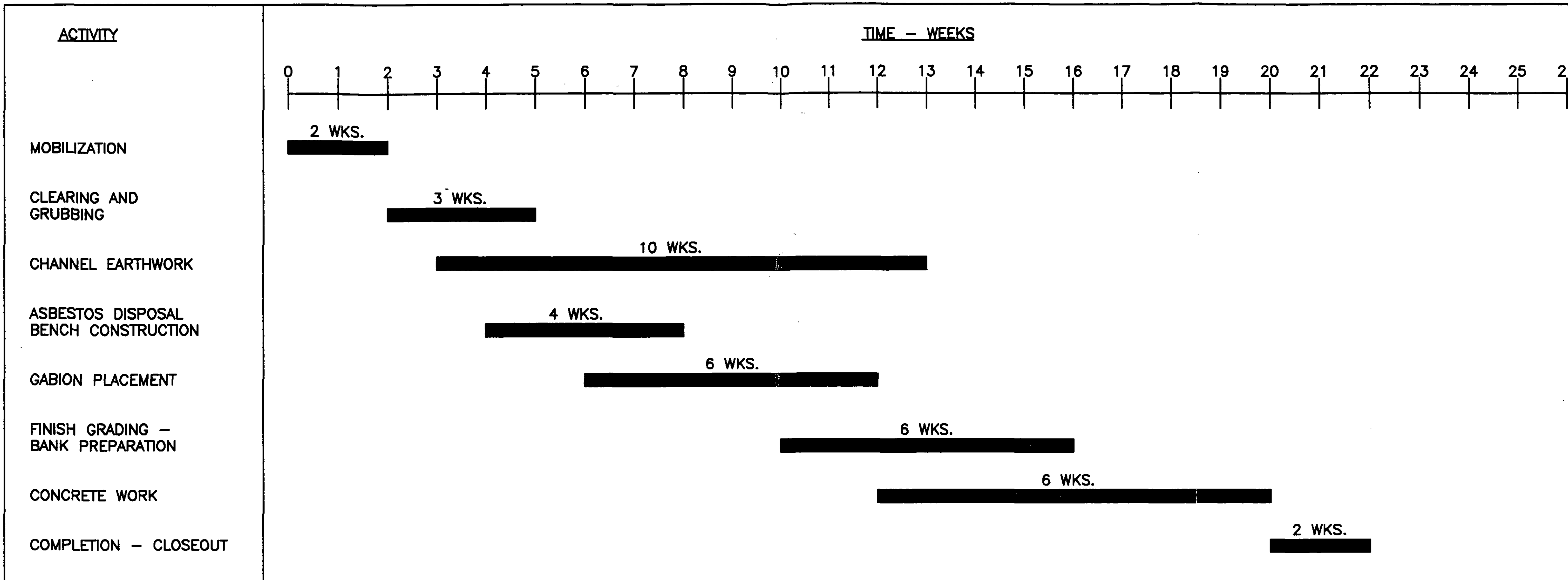

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FIGURE IV-5
ALTERNATE NO.1
CONSTRUCTION SCHEDULE

TABLE IV-1: Estimated Quantities and Opinion of Probable Cost for Alternate No. One.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	17,000 Cu. Yd.	10.00	170,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	14,500 Sq. Yd.	40.00	580,000.00
6" Geoweb 8" Conc. Syst.	11,800 Sq. Yd.	40.00	472,000.00
8" Geoweb 10" Conc Syst.	12,400 Sq. Yd.	50.00	620,000.00
Geotextile Fabric	24,200 Sq. Yd.	2.00	48,400.00
6" Granular Filter	24,200 Sq. Yd.	5.00	121,000.00
Sub Total			$ 2,164,400.00
Construction Contingencies (20%)			$ 432,900.00
TOTAL			**$2,597,300.00**

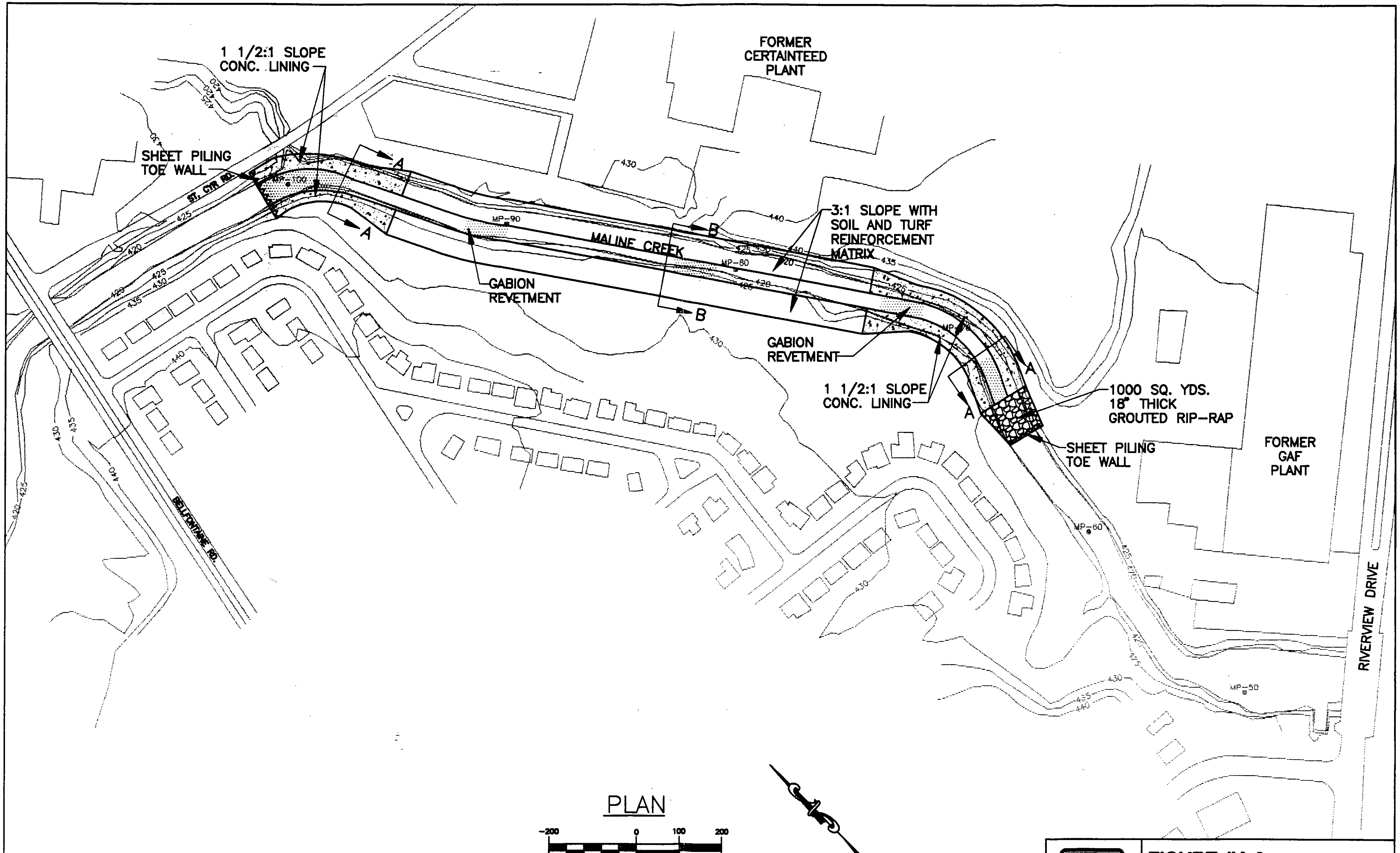

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FIGURE IV-6
ALTERNATE NO.2 PLAN

Both banks of the creek within the tangent reach between the two bends will be earth fill constructed at 3 to 1 slopes and will be surfaced with a vegetated turf reinforcement matrix. The bend embankments will be constructed at 1 1/2 to 1 slopes and will be lined with 8 inches thick Geoweb system infilled and capped with 10 inches of concrete (Figure IV-7).

The channel bed will be lined with a 12 inch thick gabion revetment, while approximately 1000 square yards of 18 inches thick grouted riprap will be placed at the downstream end of the new construction. Fifteen feet deep sheet piles will be placed across the channel's upstream and downstream ends to prevent undermining and headcutting.

This Alternate can be completed in 18 weeks (Figure IV-8). Its construction material quantities and opinion of probable cost are contained in Table IV-2.

4.4 Alternate No. Three

This alternate is similar to Alternate No. Two except that the 3 to 1 sloped reinforced earth embankment on the northeast side of the creek between the bends is replaced with a 2 to 1 sloped 6 inch thick Geoweb confinement system infilled with 8 inches of concrete (Figures IV-9 and IV-10). All other features including the 1000 square yard riprap lining at the downstream end and the sheetpile channel end toe walls remain the same.

This Alternate can also be completed in 18 weeks (Figure IV-11). Its construction material quantities and opinion of probable cost for this alternate are contained in Table IV-3.

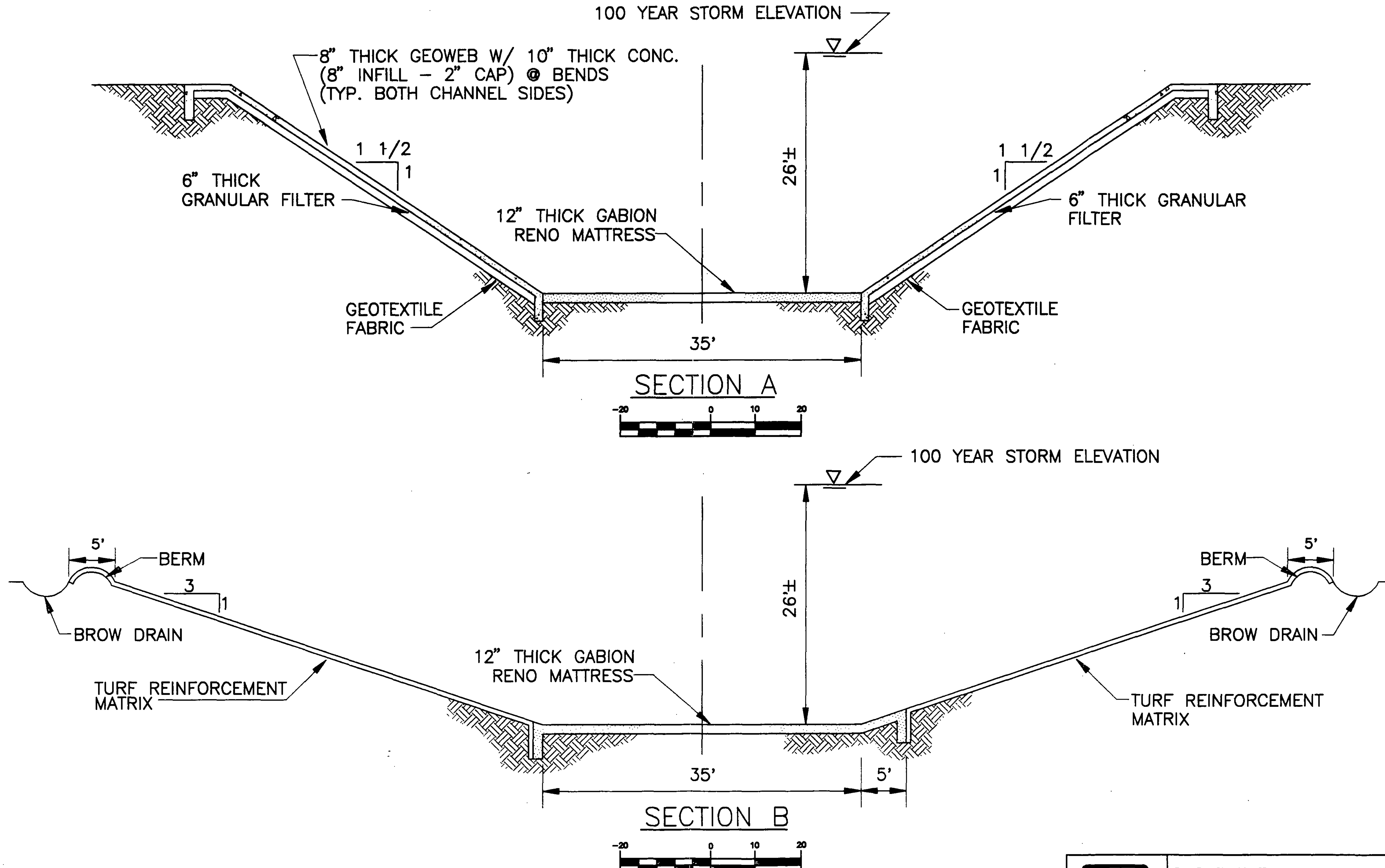

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FIGURE IV-7
ALTERNATE NO.2
SECTIONS

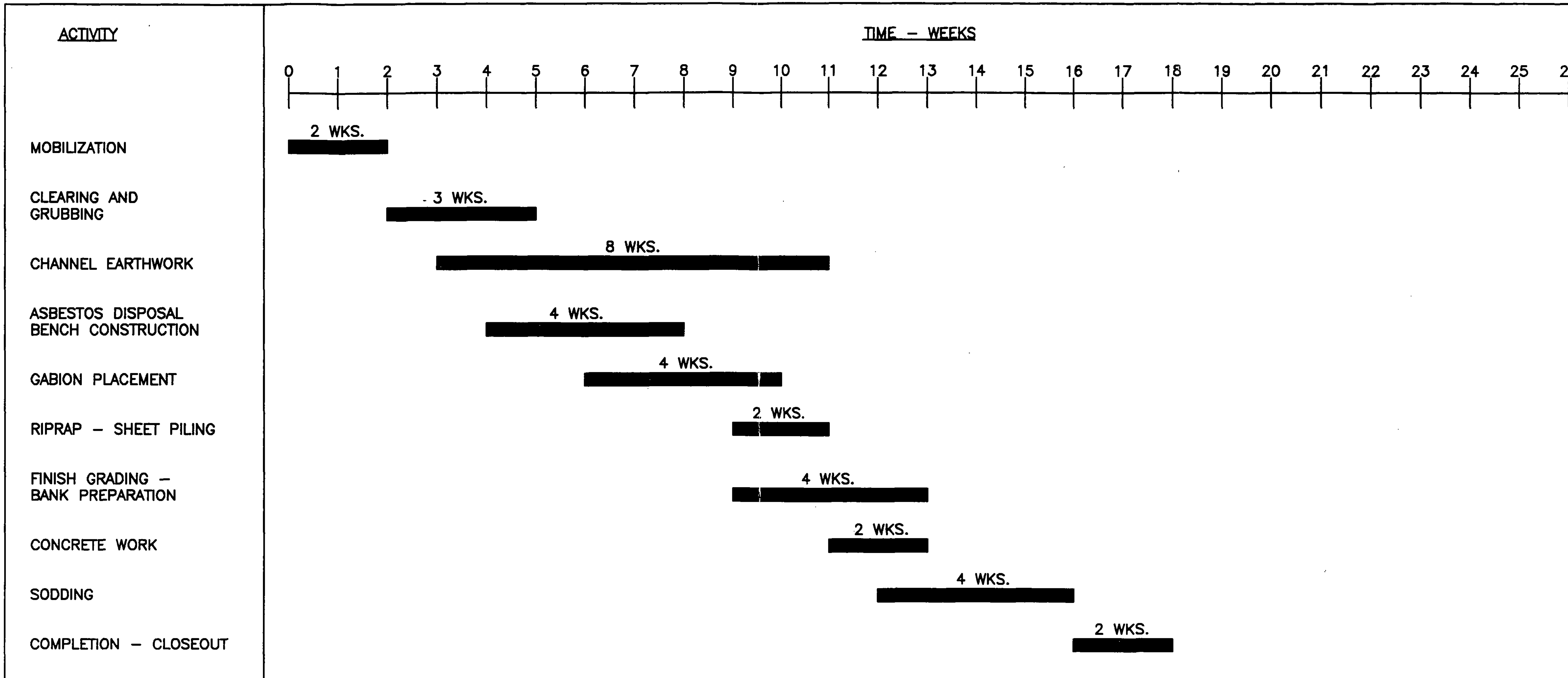

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FIGURE IV-8
ALTERNATE NO.2
CONSTRUCTION SCHEDULE

TABLE IV-2: Estimated Quantities and Opinion of Probable Cost for Alternate No. Two.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	12,000 Cu. Yd.	10.00	120,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	7,400 Sq. Yd.	40.00	296,000.00
8" Geoweb 10" Conc. Syst.	5,800 Sq. Yd.	50.00	290,000.00
Geotextile Fabric	5,800 Sq. Yd.	2.00	11,600.00
6" Granular Filter	5,800 Sq. Yd.	5.00	29,000.00
Turf Reinforcement Matrix and Soil	15,000 Sq. Yd.	6.00	90,000.00
Sod	15,000 Sq. Yd.	2.00	30,000.00
Sheet Piling	3,000 Sq. Ft.	20.00	60,000.00
Grouted Riprap	1,000 Sq. Yd.	35.00	35,000.00
Sub Total			$1,114,600.00
Construction Contingencies (20%)			$ 223,400.00
TOTAL			$1,338,000.00

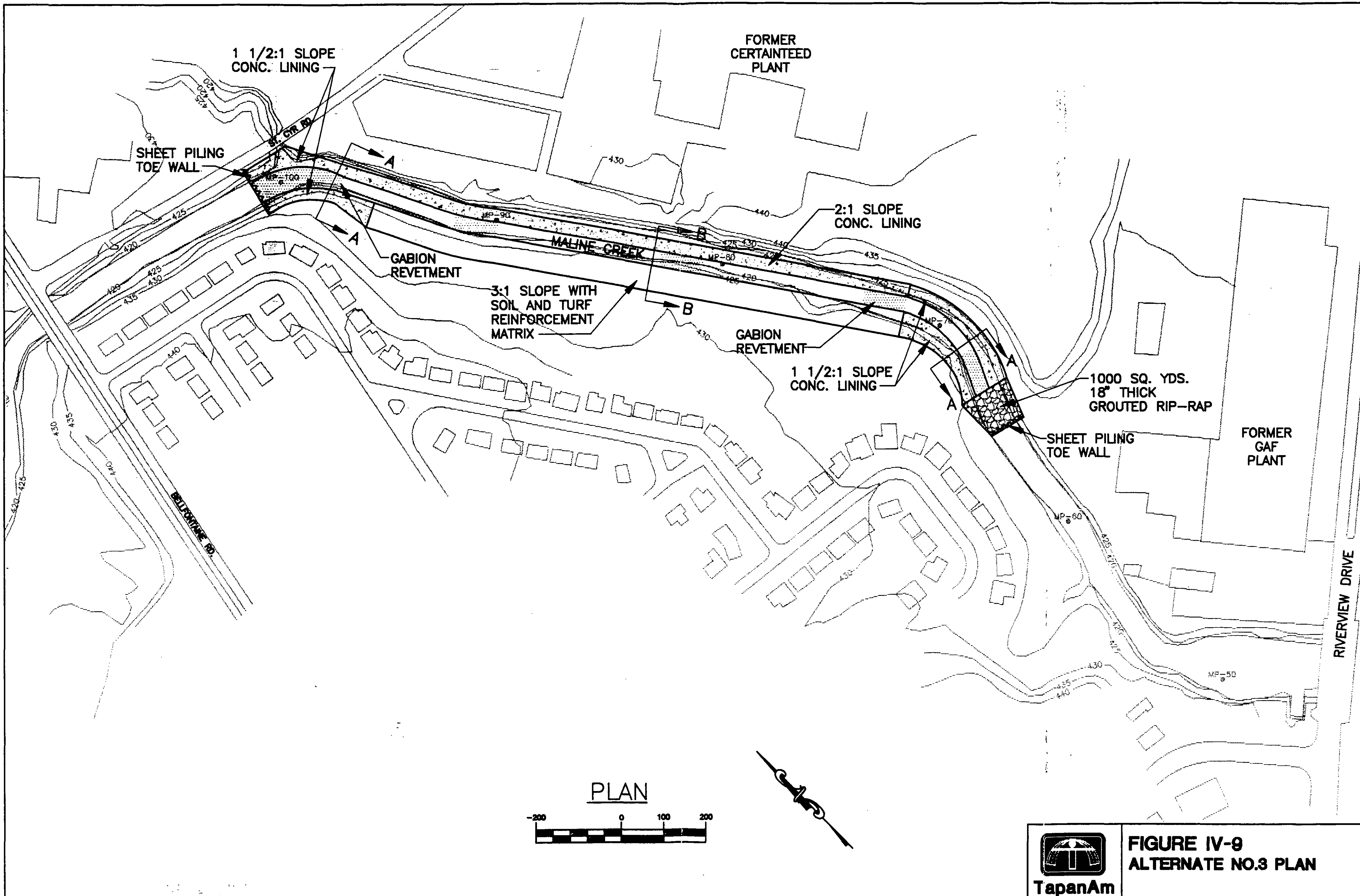

FIGURE IV-9
ALTERNATE NO.3 PLAN

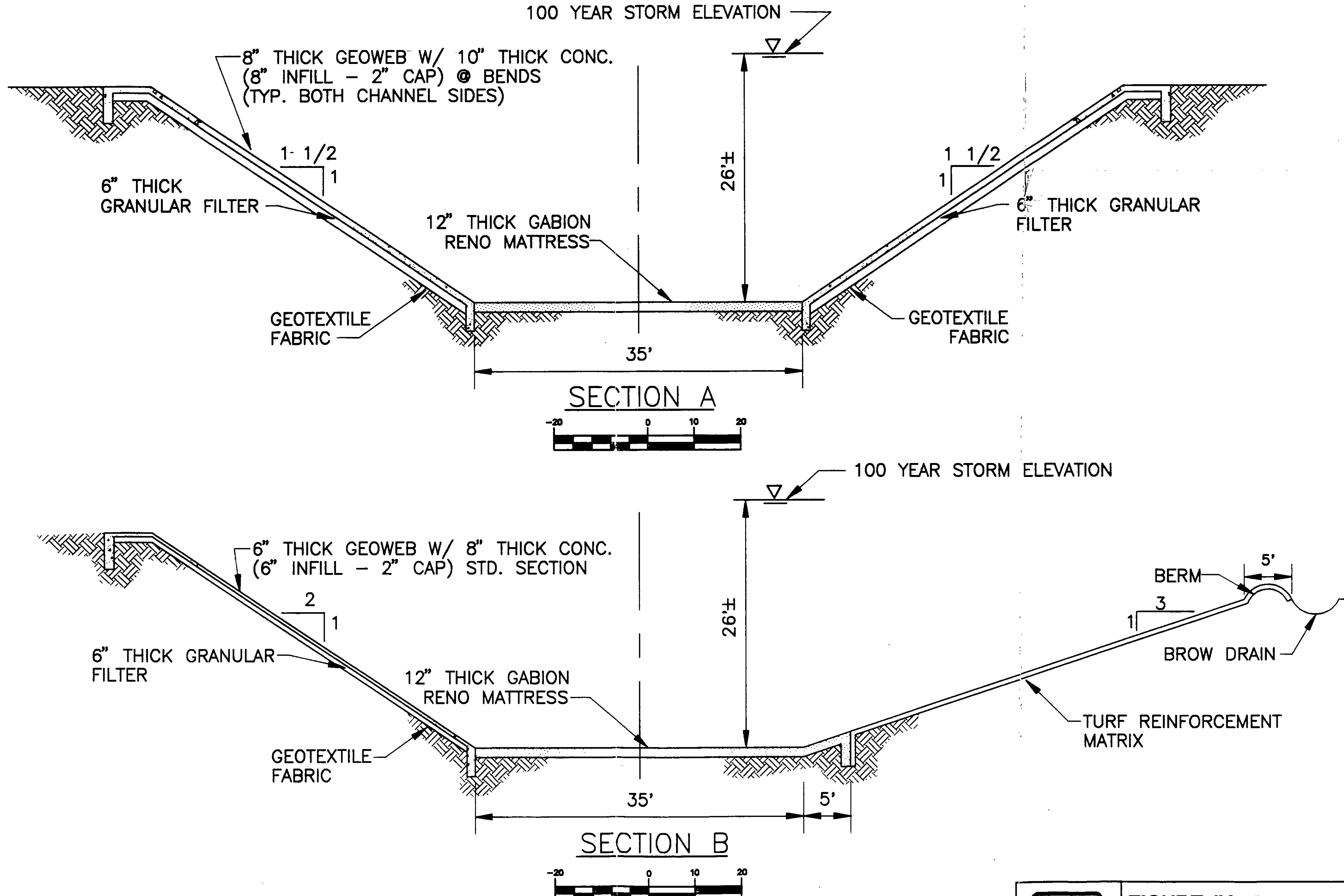

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FIGURE IV-10
ALTERNATE NO.3
SECTIONS

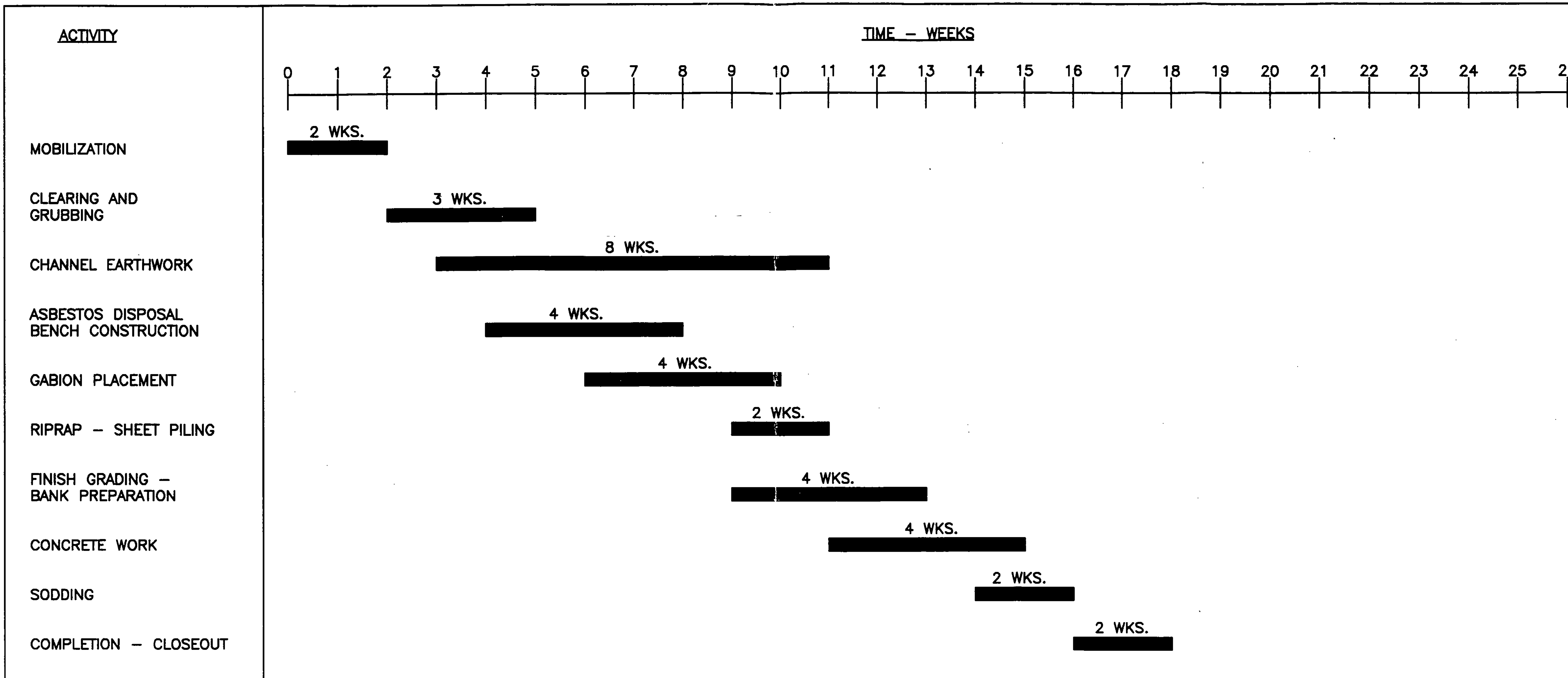

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FIGURE IV-11
ALTERNATE NO.3
CONSTRUCTION SCHEDULE

TABLE IV-3: Estimated Quantities and Opinion of Probable Cost for Alternate No. Three.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	10,000 Cu. Yd.	10.00	100,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	7,400 Sq. Yd.	40.00	296,000.00
8" Geoweb 10" Conc. Syst.	5,800 Sq. Yd.	50.00	290,000.00
6" Geoweb 8" Conc. Syst.	5,600 Sq. Yd.	40.00	224,000.00
Geotextile Fabric	11,400 Sq. Yd.	2.00	22,800.00
6" Granular Filter	11,400 Sq. Yd.	5.00	57,000.00
Turf Reinforcement Matrix and Soil	8,500 Sq. Yd.	6.00	51,000.00
Sod	8,500 Sq. Yd.	2.00	17,000.00
Sheet Piling	3,000 Sq. Ft.	20.00	60,000.00
Grouted Riprap	1,000 Sq. Yd.	35.00	35,000.00
Sub Total			$1,305,800.00
Construction Contingencies (20%)			$ 261,200.00
TOTAL			**$1,567,000.00**

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4.5 Alternate Discussion

4.5.1 Alternate No. One

This Alternate is probably the most effective long term means of controlling erosion and scour in this portion of Maline Creek. It will provide the greatest protection against re-exposure of the encapsulated asbestos scrap both along the present channel bank and in the former channel fill areas. It also represents a fundamentally different approach to solving some of the problems from that of the other two alternatives. Alternates Two and Three rely primarily upon improved channel geometry of bed and bank reinforcement to resist both the current induced dynamic forces and the local rainfall runoff or receding flood water hydraulic forces. Alternate One, however, affords superior resistance to those forces and increased protection against bank failure due to saturated soil conditions. It does so by reducing the frequency and intensity of local floods.

The restricted conveyance capacity of Maline Creek from Bellefontaine Road to the MSD drop structure subjects the surrounding area to frequent flooding. Even waters from the 10% (10 year) storm exceed the channel's banks, while waters from the 1% (100 year) storm inundate homes in Bellefontaine Neighbors as well as the former GAF and Certainteed factories. Evidence of this is clearly seen in the Corps of Engineers Re-evaluation Report Water Surface Profiles and in Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps. As mentioned earlier the advancing and receding flood waters cause overbank surface erosion, damage banks through gullying and rilling, and promote saturated soil bank failure through leaching and differential hydrostatic pressure loading.

Alternate One will be designed to eliminate flooding during storms of 1% (100 year) or lessor magnitude. It will do so by increasing the available channel flow area; reducing the channel roughness and therefore friction resistance to flow; and most importantly by shifting the channel water surface control section to the MSD drop structure. The 1% storm will then be conveyed within the new channel banks from Bellefontaine Road to the structure. Only local rain falling on the contiguous areas in the immediate vicinity of the reach would saturate the soil or contribute sheet flow to the channel.

The unprismatic, brush, tree, and rubble lined Certainteed-GAF channel reach from Bellefontaine Road to the MSD drop structure produces the high flood water elevations now seen in the area by severely restricting flow. The water surface through the concrete paved drop structure is, however, lowered dramatically (over 7 feet during the 1% storm) and would also be lowered in the Certainteed-GAF reach if the upstream channel were improved to increase conveyance. Alternates Two and Three leave approximately 600 feet of unimproved channel in place between the east bend and the drop structure. This unimproved portion of the creek will remain a restriction to flow and will have the same kind of backwater effect seen presently. Flood water elevations will, therefore, remain essentially as high as they are now if either of those two alternates is selected. Alternate One differs in that it provides for comprehensive channel improvements including a completely lined section throughout the reach. The enhanced flow area and reduced friction resistance will result in higher velocities and consequently increased channel capacity or conveyance. This will eliminate the flooding during 1% (100 year) or lesser storms and its subsequent adverse effects.

Unlike the other two alternatives, Alternate One also includes channel improvements along the reach parallel to St Cyr Road from Bellefontaine Road to the west bend. These improvements are recommended to prevent the creek from re-establishing itself in its former channel. As a consequence of Maline Creek's "tendency" to return to its meandering state, St. Cyr Road is being undermined; scour, and erosive forces are operating at the mouth of the tributary just upstream of the bend. By extending the improvements to Bellefontaine Road, Alternate One contains the forces to establish a smooth transition through the curve between two prismatic tangent channel sections.

4.5.2 **Alternate No. Two**

This alternate represents the least investment which could reasonably be expected to solve the immediate problems presented by the site. It is only a fair solution, however, because of uncertainties in the effectiveness of the reinforced soil bank in this particular application.

The two bends where scour poses the greatest problem are to be well armored with concrete, but the banks on both sides of the creek along the tangents between the bends are to be laid in at relatively mild slopes and then protected with a vegetated turf reinforcement matrix. Although channel hydraulics are improved. This alternate does not draw down flood water surface profiles. Thus the associated erosion and pressure forces previously mentioned will remain. Added to this is the natural tendency for fines to infiltrate through soil banks as hydrostatic pressure is relieved. This results in the loss of supporting material as well as in the fluid loading seen under frequent flooding conditions. The Simons, Li, and Associates study cited this very combination as the likely cause of failure of many four inches thick mesh reinforced concrete channel linings with

2 to 1 sloped banks often used in the watershed. The mild slope proposed, turf reinforcement matrix, and a well established vegetative cover with an extensive root system may well control those processes. But only a test of the system on site will yield enough information to provide confidence in its long term viability.

The St. Cyr Road undermining process in advance of the Riverview Branch Tributary bend will also remain with this alternate. The undermining currents can be blocked, but cannot be eliminated unless the channel is fully paved back to Bellefontaine Road. Periodic maintenance inspections and channel repair of scour holes upstream of any sheet piling placed will be needed.

4.5.3 **Alternate No. Three**

This alternate addresses some of the uncertainties inherent in Alternate Two. By paving the asbestos scrap material containing northeast banks with concrete completely from bend to bend and by providing proper drainage and filtration of the substrate, the concerns related to fluid pressure and soil infiltration are somewhat alleviated. These measures will also increase the resistance capacity of the bank to the applied fluid forces, but will not change the frequency of loading as long as the flooding problems remain. As with Alternate Two, the St. Cyr Road undermining process is not completely corrected in this solution.

SECTION V

CONCLUSIONS & RECOMMENDATIONS

SECTION V

CONCLUSION - RECOMMENDATIONS

Alternate One represents the best solution to the problems presented by the Certainteed-GAF asbestos dump site at Maline Creek in St. Louis County, Missouri. It is most effective in sealing the asbestos scrap into a protective envelope that will shield it from natural erosive forces within the channel, and is the only solution which eliminates frequent flooding as a problem source. It provides tighter control over the creek's "meandering tendencies", has relatively low maintenance requirements, and offers excellent assurance against eventual re-exposure of the asbestos. Given the comprehensiveness and relative permanence of the solution, the higher anticipated construction costs of approximately 2,600,000 dollars represents the greatest possible long term value. If fiscal constraints prevent implementing Alternate One, a comprehensive solution incorporating some of its more important flood and "meandering" control features into Alternate Three is suggested. Such an approach might be based on a project target budget of 2,000,000 dollars. Economies would be realized by relaxing some design criteria. Rather than establishing the 1% (100 year storm) as the project flood frequency standard, for example, the 2% (50 year storm) or 4% (25 year storm) might be stipulated. Channel improvements would still be constructed from Bellefontaine Road to the MSD drop structure, but lower conveyance requirements would permit higher friction resistance to flow and therefore less need for expensive concrete lining on the non asbestos containing south bank. Other design elements might also be prioritized to insure maximum protection for the least expenditure. Lining only the north bank along St. Cyr Road between Bellefontaine Road and the west ("tributary") bend would offer greater "meandering" control than Alternates Two and Three at a lower cost than Alternate One.

As a minimum solution, TapanAm Associates recommends Alternate Three. It is our belief that the 229,000 dollar additional cost over that of Alternate Two is entirely justified by the superior protection afforded the asbestos containing north bank by a concrete lining. Although turf reinforcement matrix is an excellent product of proven high performance, it is not recommended for use where the risk of future re-exposure of asbestos is of concern.

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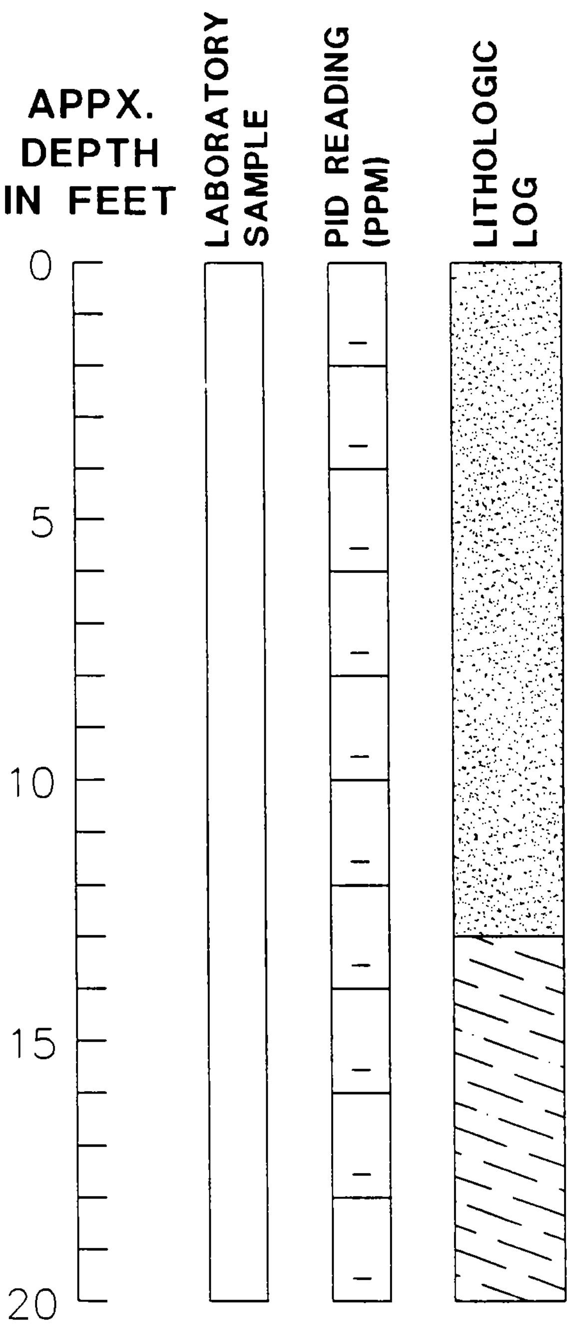
APPENDIX A

BOREHOLE LOGS

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-1 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

SURFACE (WEEDS)

CEMENT ASBESTOS MATERIAL MIXED WITH SAND, GRAVEL AND SILTY CLAY

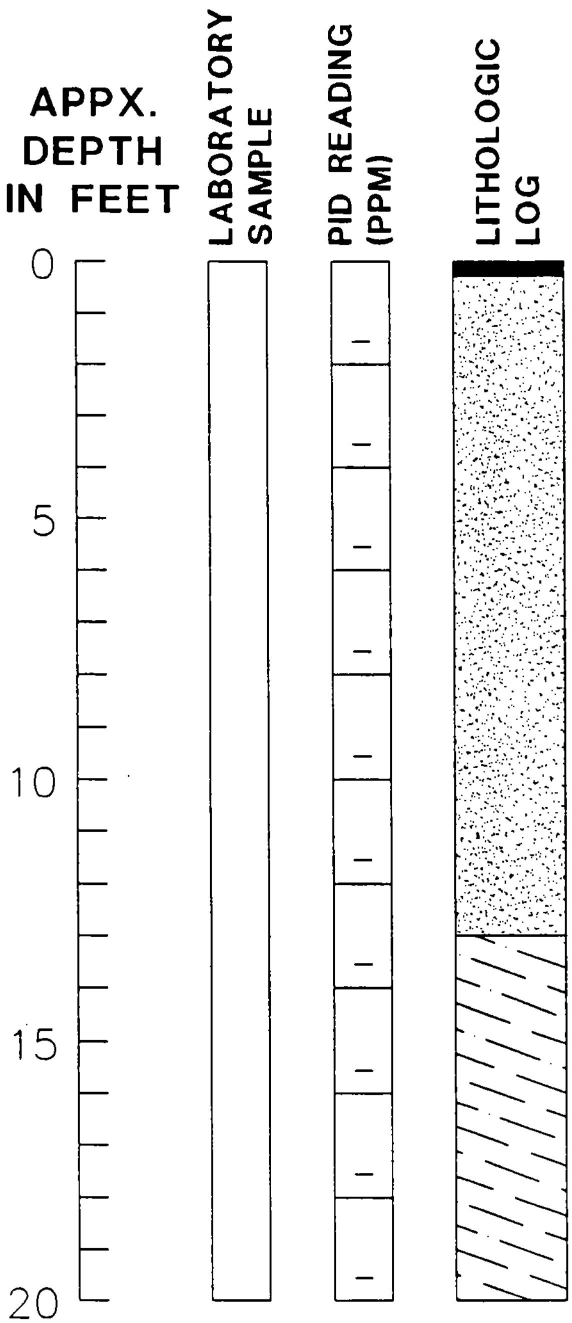
DARK BROWN SILTY CLAY

END OF BORING

psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-2 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

ASPHALT (SURFACE)

CEMENT ASBESTOS MATERIAL MIXED WITH FINE AND COARSE SAND

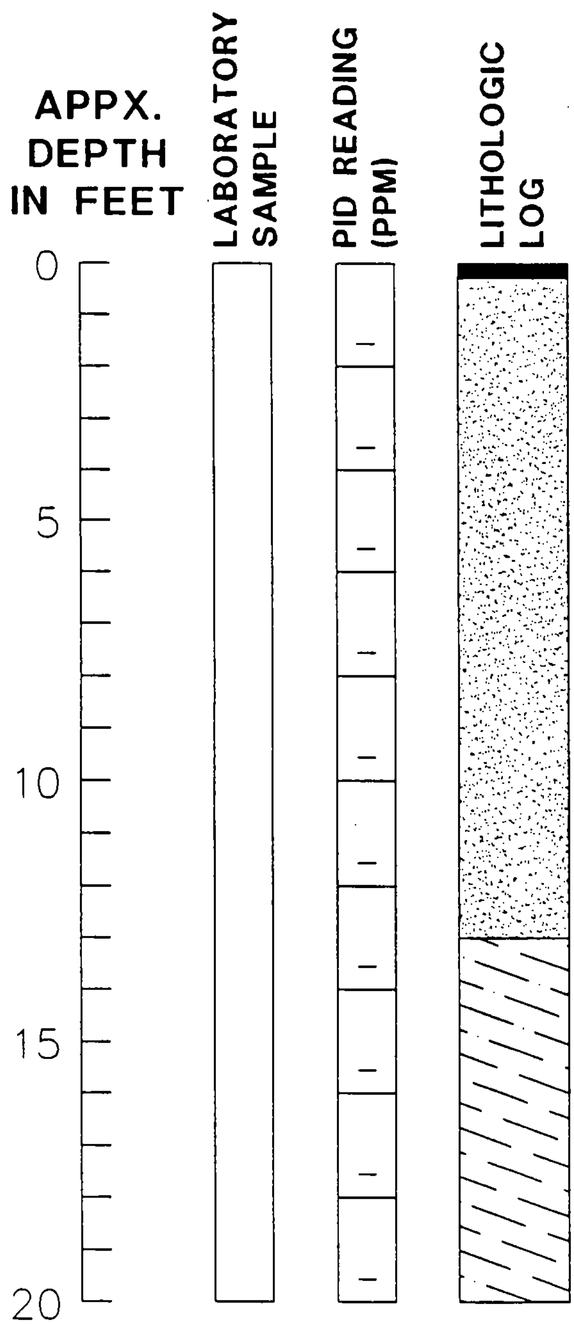
DARK BROWN SILTY CLAY (WET)

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	SOIL BORING LOG	SOIL BORING IDENTIFICATION: B-3
		PROJECT NUMBER: 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	LOCATION: ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	DRILLING METHOD: PROFILE AUGER	SAMPLING INTERVAL: INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	BOREHOLE DIAMETER: 3.5 INCH O.D.	SAMPLING METHOD: PROFILE AUGER
DRILLER: M. SIMMERING	TOTAL BORING DEPTH: 20 FEET	DATE BORING COMPLETED: DEC. 12, 1992



LITHOLOGIC DESCRIPTION

ASPHALT (SURFACE)

FINE AND COARSE SAND MIXED WITH SMALL AMOUNTS OF ASBESTOS MATERIAL

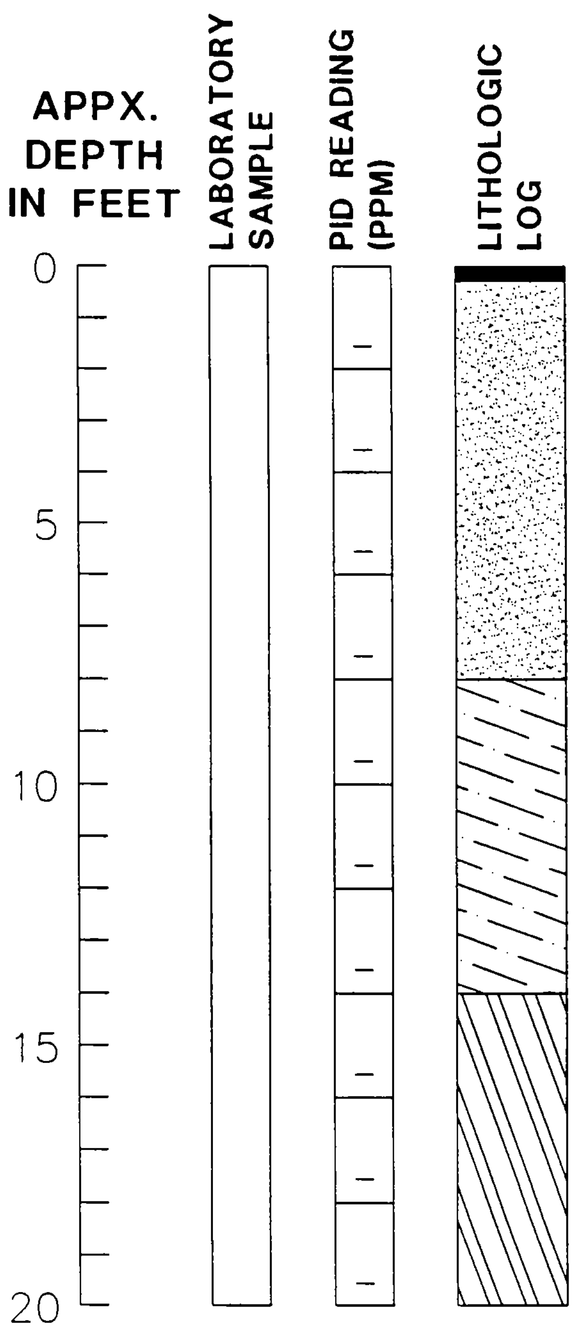
DARK BROWN SILTY CLAY (WET)

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-4 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

ASPHALT (SURFACE)

FINE AND COARSE SAND MIXED WITH SMALL AMOUNTS OF ASBESTOS MATERIAL

BROWN SILTY CLAY

GREY MOTTLED BROWN SILTY CLAY (WET) TRACE OF ASBESTOS MATERIAL

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-5 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET | **LABORATORY SAMPLE** | **PID READING (PPM)** | **LITHOLOGIC LOG**

LITHOLOGIC DESCRIPTION

0

SURFACE (WEEDS)

–

–

GREY FINE MEDIUM SAND WITH SOME ASBESTOS MATERIAL

5

–

–

BROWN SILTY CLAY WITH
VERY SMALL AMOUNTS OF ASBESTOS MATERIAL (WET)

10

–

–

–

15

–

DARK BROWN SILTY CLAY

–

–

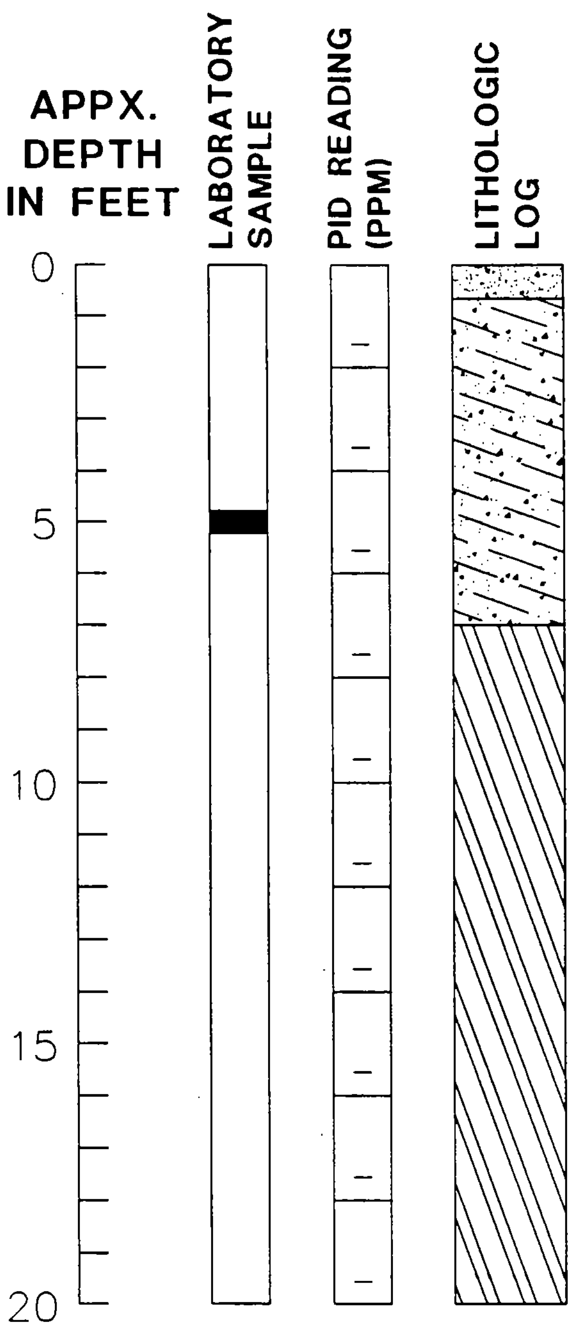
20

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	SOIL BORING LOG	SOIL BORING IDENTIFICATION: B-6
		PROJECT NUMBER: 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	LOCATION: ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	DRILLING METHOD: PROFILE AUGER	SAMPLING INTERVAL: INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	BOREHOLE DIAMETER: 3.5 INCH O.D.	SAMPLING METHOD: PROFILE AUGER
DRILLER: M. SIMMERING	TOTAL BORING DEPTH: 20 FEET	DATE BORING COMPLETED: DEC. 12, 1992



LITHOLOGIC DESCRIPTION

SURFACE (GRAVEL)

LIGHT BROWN FINE COURSE SAND WITH SOME GRAVEL

BROWN SILTY CLAY/TRACE OF GRAVEL WITH SMALL AMOUNTS OF ASBESTOS MATERIAL

DARK GREY SILTY CLAY (WET)

END OF BORING

Professional Service Industries, Inc.
4820 West Fifteenth Street
Lawrence, Kansas 66049

SOIL BORING LOG

SOIL BORING IDENTIFICATION:	B-7
PROJECT NUMBER:	60829051
PROJECT:	MALINE CREEK ASBESTOS ABATEMENT
LOCATION:	ST. LOUIS, MISSOURI
ENGINEER:	K. DEMOTT
DRILLING METHOD:	PROFILE AUGER
SAMPLING INTERVAL:	INTERMITTANT
DRILLING CONTRACTOR:	PSI, INC.
BOREHOLE DIAMETER:	3.5 INCH O.D.
SAMPLING METHOD:	PROFILE AUGER
DRILLER:	M. SIMMERING
TOTAL BORING DEPTH:	20 FEET
DATE BORING COMPLETED:	DEC. 12, 1992

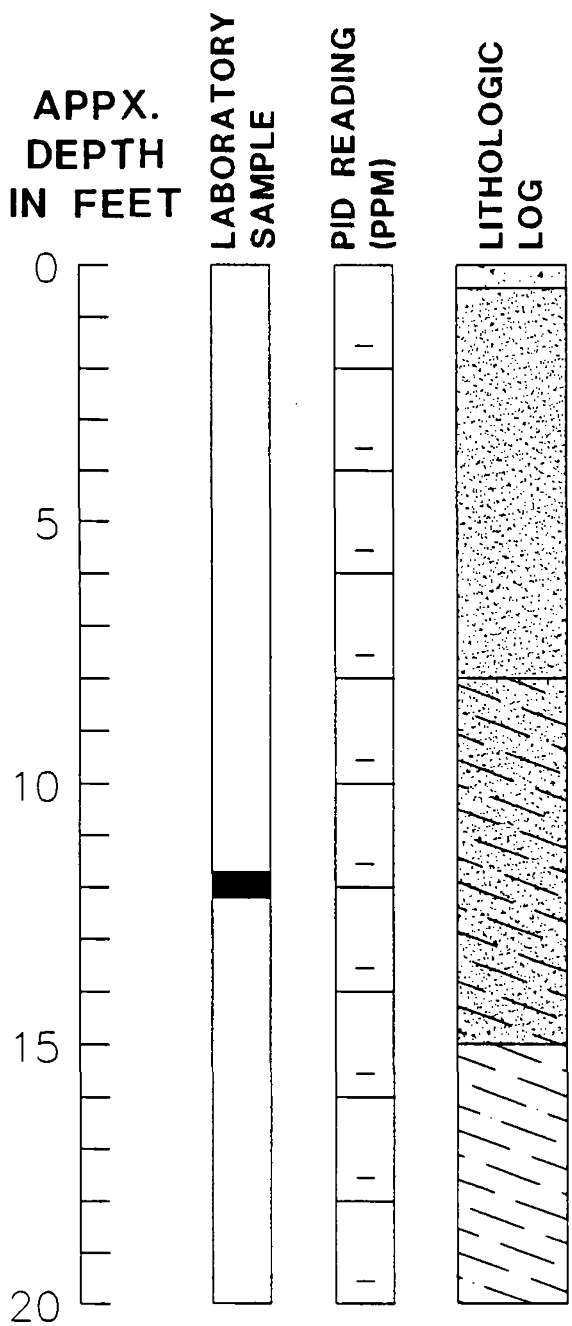
APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC DESCRIPTION
0			SURFACE (CONCRETE)
0–3		–	BROWN FINE TO MEDIUM SAND
3–20		–	BROWN SILTY CLAY WITH SOME ASBESTOS MATERIAL
20			END OF BORING

PID readings per 2-ft interval (0–20 ft): – – – – – – – – – –

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	# SOIL BORING LOG	SOIL BORING IDENTIFICATION: B-8 PROJECT NUMBER: 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

SURFACE (CONCRETE)

FINE MEDIUM SAND MIXED WITH ASBESTOS MATERIALS

BROWN SILTY CLAY (WET) MIXED WITH ASBESTOS MATERIALS

DARK BROWN SILTY CLAY

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-9
		PROJECT NUMBER: 60829051
PROJECT: MALINE CREEK ASBESTOS ABATEMENT		**LOCATION:** ST. LOUIS, MISSOURI
ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

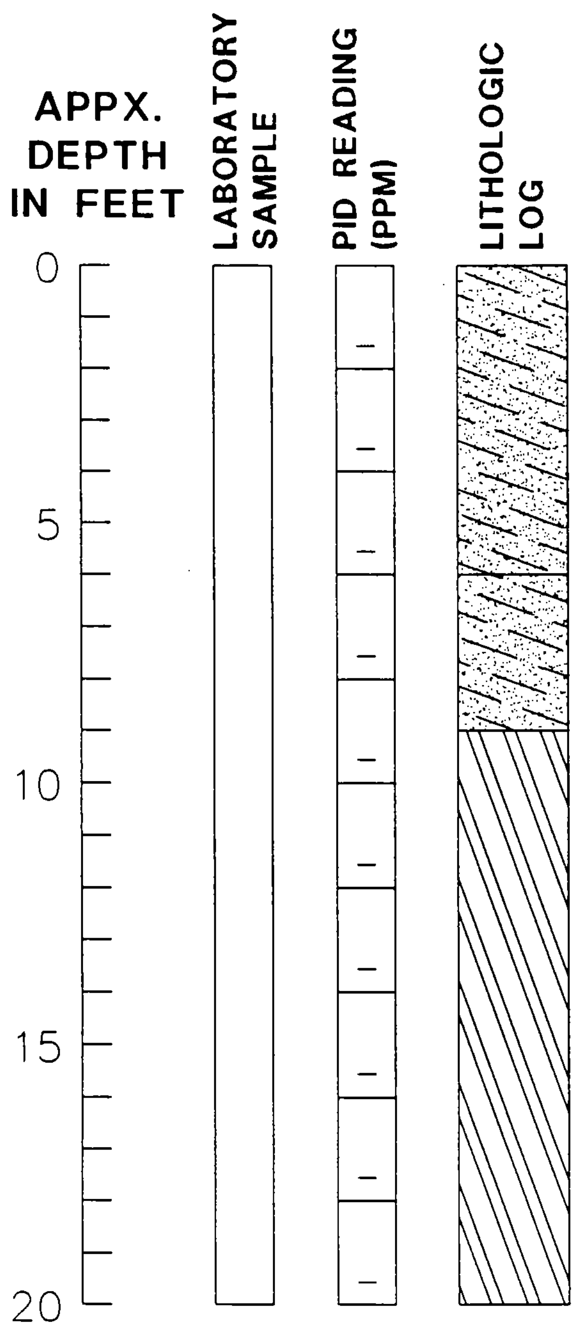
APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0				SURFACE (GRASS)
0–7		– – – –		BROWN SILTY CLAY WITH SMALL AMOUNTS OF ASBESTOS MATERIALS
7–20		– – – – – – – – – –		BROWN SILT CLAY
20				END OF BORING

Depth scale: 0, 5, 10, 15, 20

Professional Service Industries, Inc.
4820 West Fifteenth Street
Lawrence, Kansas 66049

SOIL BORING LOG

SOIL BORING IDENTIFICATION:	B-10
PROJECT NUMBER:	60829051
PROJECT:	MALINE CREEK ASBESTOS ABATEMENT
LOCATION:	ST. LOUIS, MISSOURI
ENGINEER:	K. DEMOTT
DRILLING METHOD:	PROFILE AUGER
SAMPLING INTERVAL:	INTERMITTANT
DRILLING CONTRACTOR:	PSI, INC.
BOREHOLE DIAMETER:	3.5 INCH O.D.
SAMPLING METHOD:	PROFILE AUGER
DRILLER:	M. SIMMERING
TOTAL BORING DEPTH:	20 FEET
DATE BORING COMPLETED:	DEC. 12, 1992



LITHOLOGIC DESCRIPTION

BROWN SILTY CLAY MIXED WITH ASBESTOS MATERIALS

DARK BROWN SILTY CLAY
MIXED WITH ASBESTOS MATERIALS (WET)

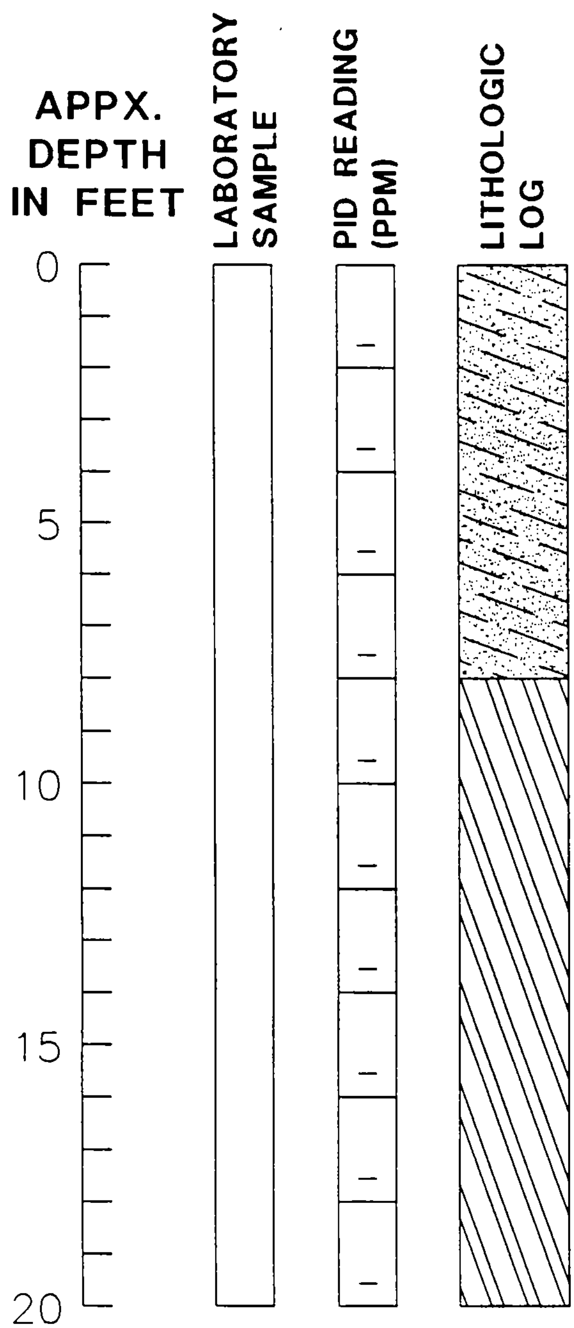
GREY CLAYEY SILT

END OF BORING

psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-11 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

BROWN SILTY CLAY MIXED WITH ASBESTOS MATERIALS

DARK GREY CLAYEY SILT (WET)

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	SOIL BORING LOG	SOIL BORING IDENTIFICATION: B-12 PROJECT NUMBER: 60829051
PROJECT: MALINE CREEK ASBESTOS ABATEMENT		**LOCATION:** ST. LOUIS, MISSOURI
ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0–8		–		BROWN SILTY CLAY AND GRAVEL MIX WITH SMALL AMOUNTS OF ASBESTOS MATERIALS
8–20		–		BROWN GREY CLAYEY SILT (MOIST) MIXED WITH ASBESTOS MATERIALS
20				END OF BORING